MONTANA FARMERS' BULLETIN NUMBER 1.

DRY LAND GRAINS.

DRY LAND FARMING

AND KINDRED TOPICS.

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LIST OF ILLUSTRATIONS

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FOREWORD.

The development of her resources must appeal to every loyal citizen of Montana. Here is an area which, if as thickly settled as some of the Atlantic states, would support 40,000,000 people, without considering the portions classed as range, forest reserve or mountain.

No part of the United States presents as interesting a field to the engineer in search of power as the rapids and cataracts of Rocky Mountain rivers. Of even greater importance are the fertile bench lands of the eastern and northern part of the state. Whether by their own initiative or induced by the alluring pictures drawn by agents of land companies and immigration offices, settlers are pouring across our borders and establishing homes. The success and prosperity of these people means much to the commonwealth. Not alone do we regard the wealth created and the increased population; but of a paramount interest are the quality and intelligence of our citizenship. Failure of crops, owing to a lack of understanding of Montana conditions, means disaster and ruin to the settler and a heavy burden upon the state. A repetition of the terrible experience of the pioneers in western Kansas and Nebraska during the early nineties, would mean the abandonment and desolation of whole townships.

It becomes, therefore, the duty of the state to instruct these new comers in the methods which have brought success to others similarly situated. We should bend every effort, not towards inducing more settlers to make their homes among us, but rather towards the success and prosperity of those we already have. A prosperous community attracts people like steel to a magnet.

Not only is it the duty of the state to promote the welfare of its people by teaching them how to succeed, but it is also the best possible investment. The few thousands spent in this way create an endowment which will yield a splendid revenue for all time. It is therefore wise and expedient to build up our industries, fostering them with particular care.

From small beginnings the farmers' institute has grown into a powerful factor. It has brought instruction to over 13,000 people during the past year in every county of the state, at over 160 institute sessions. It reaches those who are unable to attend our higher institutions of learning. Those who by reason of age and the burdens and responsibilities of life, have relinquished their hopes of school training, have here an opportunity to learn the best of science and experience in their vocation. At the institute rostrum are gathered the best informed scientists and men of richest experience, who there teach the lessons they themselves have learned.

The scope of the work is broad and includes every conceivable subject pertaining to the farm and the home.

A substantial increase in the state appropriation for institute work has enabled the department to increase its activities very materially during the past year, when nearly double the institute attendance of previous years has been recorded.

The field of service is immense and may be yet further extended. As a branch of farmers' institute work it is hoped and confidently expected that this publication will prove both timely and valuable to the people of Montana.

DEMONSTRATION AT EXPERIMENT FARM, Forsyth, July 21, 1908.

HOW TO GET THE CROP.

Splendid crops are being grown in Montana on lands that get only 12-18 inches of rainfall without irrigation.

The secret of success lies in holding the rainfall of two seasons for one big crop. Summer tillage to maintain a soil mulch will conserve from seven to ten inches of water.

Seed should be drilled into moist earth and the soil packed about it.

From two to three pecks of seed per acre is enough.

Harrow young grain in the spring to make a mulch and retain the moisture.

Early seeding is best.

Keep all uncropped land cultivated and free from weeds during spring and summer. Harrow after each rain and whenever a crust begins to form.

Turkey red, gold coin and lofthouse wheats, sixty-day oats and white hulless barley have succeeded best on dry lands. Intertilled crops, e. g. corn, potatoes, beans, etc., are good in rotation. Alfalfa, brome grass and barley make the best forage. Flax succeeds well on dry land.

Feed as much stock on the farm as possible. Sell the crop in concentrated form.

Don't attempt to plant too much ground the first season. It will produce a double harvest after a season of cultivation. Crop the land only alternate years.

Flax, oats, barley and vegetables may be sown the first spring to tide the settler over the first year; but the more land he plows and summer tills for next year's crop the better off he will be in the long run.

Do not sow alfalfa until the second or third season after breaking, making sure of good tilth and reserve moisture, then sow the seed without a nurse crop, as early in the spring as possible.

CHAPTER I.

DRY LAND FARMING IN MONTANA*

DISTRICTS WHERE DRY FARMING PROMISES GREATEST SUCCESS IN MONTANA.

By F. B. LINFIELD.

THE AREA OF LAND TO CROP.

Montana is the third largest state of the Union, with an extreme length along the Canadian border of about 570 miles and an extreme width, north and south, of about 300 miles, with an area of 145,310 square miles or 92,998,400 acres. Of this area perhaps 26,000,000 to 27,000,000, acres are classed as mountain and forest land and about 17,345,000 acres of this are in forest reserves. About 38,000,000 to 45,000,000 acres in the state may be classed as grazing lands, that is, lands too rough or too rocky to be cultivated yet capable of producing good range grass for pasture. The remaining, 23,000,000 to 30,000,000 acres may be classed as farming lands;—areas which are comparatively level with a soil rich and deep enough to be cultivated. It is probable, however, that because of the lack of potable water and because in many districts the farming land is limited in area, that not more than twelve to fifteen million acres will be available for dry land cropping.

The result is to yet leave nearly two-thirds the area of the State as grazing lands, and the income from this large area will continue to be, in the future as in the past, live stock and live stock products. It is becoming recognized by all our stockmen that the days of the free open range, the days of the large live stock holdings are passing away. In those passing days there was little or no investment beyond the investment in cattle or sheep. No provision was made against a dry season or a hard winter. If everything was favorable the profits were large, but with adverse conditions the losses were also very large;—it was a risky business. We are

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*From Bulletin No. 63. Montana Experiment Station.

coming to a time when the range will have to be handled on another basis and the dry land methods of soil cultivation are going to help solve the range problems and help to put the range stock business on a safe and conservative basis. The profits may not be as large but the losses may be very largely eliminated. The dry land farm is going to provide winter quarters and winter feed for the live stock of the range and provide this feed where the stock is, right out on the range. The largest amount of success on these dry farms will come to those who make live stock the main market crop of their farms, the adjoining range providing the summer and the farm, the winter feed.

Fig. 1. DRY FARM RYE.

Prof. S. Fortier, who was for several years Director of the Montana Experiment Station and in charge of the irrigation work of the Station, in a recent bulletin on "Irrigation in Montana" issued by the Irrigation Division of the Office of Experiment Stations of the United States Department of Agriculture, states that at present there are about 1,000,000 to 1,125,000 acres irrigated in this state. Reasoning from two standpoints, first the available water supply and second, the availability of land to a water supply, he does not think that more than 6,000,000 acres will ever be put under irrigation in Montana and even to reach this amount we will have to use water much more efficiently than at present; in fact, we must figure on using an average of not over two acre feet of water whereas our present duty of water is about four acre feet.

Considering the above facts, it is evident that from 12,000,000 to 15,000,000 acres of farming land in the State can never be irrigated. The question then arises,—What should be done with this land and how should it be handled to return the largest amount to the people, and to the State? In the following pages of this bulletin we hope to call attention to a few facts which may help to answer this question.

THE RAINFALL OF THE STATE.

There is a very close interdependence between the vegetation of a country and the climate of that country, especially the temperature and rainfall. In a moist, hot climate we notice not alone a kind of vegetation peculiar to that country but we see also a rapid and very luxuriant growth. From this we may go to the other extreme where the hot dry desert refuses to produce any vegetation because of the lack of moisture, or, as we travel north or climb to the top of high mountains, we find that the cold prevents vegetative growth though there may be an abundance of rain or snow. Between these extremes are many kinds of climatic conditions. On the average, Montana presents a spring and early summer reasonably moist, with long sunny, summer days, followed by a dry later summer and fall and a winter that on occasions is very cold. The result is to give a natural vegetation that grows rapidly, is generally short and matures and produces seed very early in the season. The root is wiry and hardy and well able to survive great extremes of dryness and cold. These facts we must keep in mind in planning our system of cropping for the dry bench lands.

It is perhaps, worthy of note that in some thirteen years' residence in the arid west the writer has had an opportunity to visit nearly all the states making up this part of the country. It would appear that, on the average, Montana has a heavier sod and a better growth of grasses than any of the states to the south. This very fine growth of natural vegetation has been frequently commented on by men who have visited us, especially those from Utah and Idaho.

The crops that are produced on the irrigated lands of the state are proof conclusive that, if the water is provided, abundant farm crops may be grown on the farming lands of Montana. In

considering therefore the possibilities of dry land cropping in the State the writer has been making a considerable study of the rainfall of the State, or the indications of rainfall, where no weather records have been kept. Unfortunately, our sparse population in many parts of the State makes it impossible to tell accurately what is the rainfall in many districts. It was very evident early in the study of this question that to consider only averages for the State would be very misleading, as the topography of the country modifies materially the rainfall of certain sections.

After a trip to Seattle in the spring of 1904, I was much impressed with the succession of wet and dry belts as we traveled westward. Montana is classed as an arid country. Traveling westward until we cross the farthest of the Rockies,—the Bitter Root Range, we strike a strip of country on the western slope of the Bitter Root Mountains with a rainfall of twenty-five inches or over. Continuing our journey west to the valley of the upper Columbia and the Yakima and again it is very dry. We climb the Cascades and on their western slopes we find one of the wettest districts in this part of the United States.

Whether my logic is correct or not, it would seem that as the moisture laden winds blow off the Pacific Ocean and climb the Cascades much of this moisture is precipitated on the western slopes of the mountains. In crossing the lower valleys of the Columbia the air parts with but little of its moisture, but when it begins to climb up towards the Bitter Root Range again condensation takes place and we have a wetter strip of country than that either to the east or west of it.

AREAS OF MAXIMUM RAINFALL.

What was observed in these places on a large scale I thought might be reproduced on a small scale in various sections of our mountainous country. Excessive rainfall is to be looked for on the western slopes of mountains where the wind blows over a wide stretch of the valley to the west. The weather record confirms what observation would lead us to expect; we find centers of large rainfall on the western slope of the Rocky Mountain divide in Flathead county, on the westerly slope of the Highwood, the Belts and the Big Snowy Mountains in Fergus and Cascade counties, on the

western slopes of the Gallatin and Bridger ranges in Gallatin county and on the westerly slopes of the Pryor and Big Horn Mountains in Carbon county.

In travelling out to the range country and leaving the large river valleys, it seemed to me when climbing the hills to the high plateau and water shed dividing the rivers, that the sod and the vegetation became better as we climbed and the grass stayed green later in the season; the soil was of a darker color, due to more humus and the springs were more abundant. All these signs pointed to a greater rainfall and continued later in the season than in the valleys. Inquiries from range men in various parts of the State seem to lend further weight to the thought that our rain storms follow the watersheds rather than the rivers and on these watersheds precipitation is more abundant. Unfortunately, because of the sparseness of the settlements on these watersheds, the Weather Bureau has but few records that can lend support to the point taken.

THE SEASON OF GREATEST RAINFALL.

There is another peculiarity of the Montana rainfall that is interesting and of especial importance to the dry land farmer. On the coast the season of greatest rainfall is during the winter season, the lighter rainfall coming in months of June, July and August. East of the Cascades, though the rainfall is less, the winter and spring are also the wettest seasons and the summer and early fall are dry. Coming now east of the Rocky Mountains we find the maximum rainfall comes during the late spring and summer months. In a measure, the rainfall of this region is complementary to that of the coast. The importance of this fact agriculturally and to our dry farm work is that the season of maximum rainfall is at the season of the year when it is of greatest value for the growth of the crops; viz, April, May, June and July. During these months we get nearly as much rainfall as in the humid districts of the East.

Considering next the region of favorable rainfall in the state we find that the maximum rainfall is in the northwest corner. On the extreme west we have an annual rainfall of twenty-four inches. From this it decreases to twenty-two inches on the eastern boundary of Flathead County and to sixteen inches on the eastern boundary

of Teton County. The spring and early summer rainfall is about eight inches, not as large a proportion of the annual rainfall as in other parts of the State.

Again, at the headwaters of the Teton and Sun Rivers and extending over the divide down the valley to the Blackfoot River, we find the annual rainfall running up to eighteen inches and around the towns of Augusta, St. Peters and Chouteau the spring and early summer rains run up from nine to twelve inches.

Again, in Fergus County and extending down into a portion of Meagher we notice that the annual rainfall climbs from fourteen to twenty inches and the spring and early summer rains from eight to eleven inches.

In Carbon and Sweetgrass Counties with Red Lodge as a centre there is another area of large annual rainfall running up from fourteen to nineteen inches and the spring and early summer rains reaching from nine up to eleven inches.

Yet another district of large rainfall is north of Glendive on the divide between the Yellowstone and Missouri Rivers. Here again the yearly rainfall runs to eighteen inches with an average fall of eight inches for the spring and early summer months, but this record does not yet cover more than a few years. Judging only from the soil and the vegetation as seen or described by others, (as there are no weather stations located at the places), it appears that in yet a few other places favorable moisture conditions are to be found. One is on the high plateaus north of the Milk River and towards the Canadian border; another on the high land between the Milk and the Missouri Rivers in Choteau and Valley Counties. In Beaverhead County, especially on the higher bench lands surrounding the Beaverhead Valley, there seems to be rainfall enough to make dry land cropping worthy of a trial. In the southeastern part of Custer County I would also look for favorable rainfall conditions that would make dry land cropping successful. Some of these districts I have not yet found time to visit and cannot therefore speak with confidence. Any place where there is found a deep dark soil with a close tough sod I would expect to find a good rainfall. The black soil would indicate abundant humus which is formed from an abundant vegetative growth, which could only be had from a good rainfall. The same thoughts would apply to the sod on the ground.

There are also some dry areas in the State. The center of one

of them is Jefferson County but takes in the towns of Boulder, Whitehall and Butte. Not alone is the yearly rainfall light, only ten inches, but the spring and early summer rains are below six inches. This dry area reaches out into portions of Madison, Broadwater and Lewis & Clarke Counties and extends west over Silverbow, Deer Lodge and Ravalli Counties. Yet another very dry section is in the neighborhood of Glasgow in Valley County.

We ought not to leave this subject without calling attention to the precipitation in the states around us. The western portion of the Dakotas is filling up with settlers and successful crops are grown without irrigation, yet the average rainfall is no greater than in many districts in Montana; notice Williston, Dickinson and Bismarck. In South Dakota around the Black Hills there is a moist area but no more so than in many parts of Montana.

The Canadian northwest, into which thousands of American people are pouring, does not show along the line of the Canadian Pacific, any larger rainfall than many parts of Montana; QuAppelle, 17.9 inches; Swift Current, 15.6 inches; Medicine Hat, 14.9 inches and Calgary, 17.5 inches. Northern Wyoming appears to be rather dry; while Idaho presents some interesting examples of extremes.

A CONCLUSION.

There are, of course, local conditions which may modify any general conclusion that may be drawn, yet I believe that observation and experience would warrant the statement that in any portion of the State where the average yearly rainfall ranges from fourteen inches and upward and where the rainfall for the months of April, May, June and July is seven to eight inches or over, land cropped under dry farm methods ought to do well when the work is properly done. Those areas with an average of twelve inches or less of annual rainfall and with less than seven inches of rain in the spring and early summer months offer a less promising outlook.

THE VARIATIONS IN YEARLY RAINFALL.

In traveling over the State for the past few years the comment has been frequent that the country is getting dryer and the rainfall less, because the grass on the range is not now as abundant as it used to be and the springs and water holes are drying up. However,

I fear that on this point too much stress is put on present conditions. The records of the Weather Bureau, when considered over a long enough series of years, do not show any preceptible change in the rainfall.

There are, of course, some years with less and some with more than average rainfall. The crops on the dry land are going to be affected to a considerable extent by this variation in yearly rainfall. In the wetter seasons crops will generally be extra good; the average rainfall should also bring good crops. However, when the rainfall is away below the average, as it was in 1904 and 1905 at Havre, (as well as over much of northwestern Montana east of the range) when the rainfall for the two years was but 15.37 inches or but little more in the two years than the average annual rainfall, we may expect under such conditions partial or complete crop failure. Knowing that these things are to be expected occasionally, however, the farmer on the dry land takes them into consideration and plans his work and his crops accordingly.

There are two points that are favorable to Montana as compared to the states to the south. According to Bulletin P of the U. S. Weather Bureau, the probabilities for normal rainfall are 10 per cent better in Montana than in the states to the south of us; while we have more frequent rains and shorter periods of dry. weather, all very favorable factors for the dry land farmer.

Fig. 2. RYE WITHOUT IRRIGATION. Forsyth, 1908.

A LITTLE HISTORY OF DRY LAND CROPPING.

The successful cropping of the farming lands in the arid and semi-arid regions of the United States is by no means a new question. I have no means of knowing how long ago the first attempts at dry farming were made in the arid country, but I have talked with those who have done more or less in this direction for about twenty years. Probably the first systematic experiment work in this direction was done in the semi-arid belt and was the outgrowth of the desire of some of the western railroads to get settlers on the land along their lines. The name of Mr. H. W. Campbell of Lincoln, Nebraska, is inseparably linked with these first experiments. Substations in the dry belt have been maintained by the states of Nebraska, Kansas and Colorado.

While connected with the Utah Experiment Station the writer, in the winter of 1901, urged the importance of systematic study of the possibilities of dry land farming in that state and discussed with Gov. Wells of Utah, the possibility of the state providing funds for this work. As it was late in the season nothing was done. Two years later the Director of the Station in his report recommended that provision be made for dry land experiments over the state, and the Governor in his message to the Legislature of 1903 strongly recommended that an appropriation be made for this work.

The Utah Legislature passed a bill making an appropriation of $6000.00 per year for five temporary sub-stations in different parts of the state. Two years ago in 1905 they increased this appropriation to $7,500.00 per year for the continuation of the work.

In Montana dry land cropping has been carried on for several years in a few sections. In Flathead County is probably the largest area of land cropped without irrigation in the State. In Cascade County, especially on the high lands out toward the Belt and Highwood Mountains, in Gallatin County at the foot of the Gallatin and Bridger Mountains, and within the past few years, on the high plateaus of Fergus County, very successful results have been obtained by dry land methods of cropping.

In the fall of 1902, Prof. Fortier, then Director of the Montana Experiment Station, planned to urge upon the Legislature the need for an appropriation for culture studies on the dry bench lands of the State. While recognizing the need for this work, the writer urged that it was more important to strengthen the equipment of

the home Station, rather than to take hold of new work for the handling of which our facilities were inadequate. The writer's contention prevailed and the needs for further equipment at the home Station were urged upon the Legislature. However, in the spring of 1903, through the support and cooperation given by the Irrigation Division of the U. S. Dept. of Agriculture, a small tract of land was selected at Wayne, near Great Falls, upon which to test methods of dry land cropping and also to test the practicability of storing the flood waters of the spring by constructing a dam across a coulee on the farm and using this water to irrigate a small area near the house for a garden or orchard and to provide water in the barn-yard for the live stock of the farm.

During the winter of 1905 the matter of experiments on the dry bench lands of the State came up in another way. The results of experiments in other places had encouraged the Land Department of th Northern Pacific Railway to think that its lands in Montana might also be cropped successfully if proper methods were used. If this were so then there was a possibility of settling the country and making homes for the small stock farmer which would mean more traffic for the railroad. The railroad lands, therefore, were temporarily withdrawn from the market and an appeal was made to Secretary Wilson of the U. S. Department of Agriculture for help to carry on the experiments. Prof. Elwood Mead of the Irrigation Division was delegated to look up the matter and the Director of the Montana Experiment Station was also invited to a meeting at Bismarck, N. Dakota, in February, 1905. At this meeting it was arranged that the Northern Pacific Railroad would give $2500.00, the U. S. Department $1000 and the Director of the Montana Station was asked to provide $1000 per year toward the work and this sum was later appropriated by the Montana Legislature.

Soon after the meeting at Bismarck the writer took up the matter of securing funds from the Great Northern Railway for experiments on the dry land along its line. During the year, in addition to correspondence, several conferences were had with Mr. M. J. Costello, Industrial Agent of the Great Northern. Although the Great Northern has no public lands, the management of this railroad are very much interested in the development of the country along their line and they finally agreed to give $1000.00 per year for these experiments, provided a satisfactory agreement could also be made

with the Northern Pacific Railroad. It was finally agreed to drop the irrigation feature of the work for the time being. The Northern Pacific agreed to contribute $2500.00; the Great Northern, $2000.00 and the Montana Experiment Station, $1000.00 or a total of $5500.00 for the year 1906. The Montana Experiment Station agreed to provide a competent man to look after and direct the work, and was responsible for the carrying on of the experiments, gathering the data and writing up and publishing the results. The latter, however, was not to be charged against the funds contributed as mentioned above. It was also agreed that the Station would maintain three sub-stations along the line of the Northern Pacific, to be located from Billings eastward, and to establish and maintain two in addition to the station at Wayne, along the line of the Great Northern. The State has been fortunate indeed to get this generous appropriation from the railroads for the inauguration of this dry land work. We have also had generous support from the local people in some places. For the station north of Harlem the people of the town built a small house on the farm, fenced 200 acres, and drilled a well, costing them altogether in the neighborhood of $300.00. The people of Forsyth also raised $100.00 to pay for the breaking of the ground and to aid in fencing the experiment tract near that town.

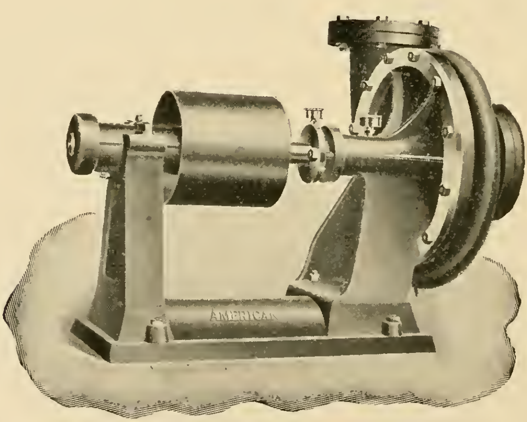


Fig. 3. HORIZONTAL PUMP.
(Courtesy American Well Works, Aurora, Ill.)

CHAPTER II

SIGNIFICANCE OF WATER IN AGRICULTURE.

All life is dependent upon water for its existence. In both plants and animals water plays an important role in the drama of development. Respiration, circulation and nutrition are impossible in the absence of water. Even the very tissues of all living organisms contain a large percentage of aqueous matter, amounting to 50 to 70 per cent of the live weight of our domestic animals and from 75 to 90 per cent of the fresh substance in the crops of the farm.

FARMING WITHOUT WATER AN UTTER IMPOSSIBILITY.

In the sense of dispensing with water entirely in the conduct of farm operations the term **Dry Farming** is a misnomer. The general acceptation of the term, which has the merit of expressive brevity, is farming in semi-arid regions with only the moisture of natural precipitation. The expression **farming above the ditch**, conveys the idea in more accurate language. Dry farming is not an absolute term, but merely relative, and is contrasted with humid or semi-humid agriculture. Generally speaking, dry farming applies to conditions of less than twenty inches annual precipitation, and it is very obvious that below this amount the greater the precipitation the more certain is successful tillage. As we approach the point of no rainfall, production rapidly diminishes until it ceases entirely when water falls below a certain point. In Montana it means tillage with 10-18 inches rainfall.

The absence of water is death. Nothing can more certainly destroy life than the absolute deprivation of water. The popular conception of eternal death involves the absence of water. Without it plants wither and die of thirst, even the microorganisms become dormant and eventually die. Life is impossible for even the briefest span without water.

It should not be considered for a moment that dry farming means farming without water. That would be impossible. It is rather the conservation or saving of a limited precipitation to secure the maximum growth of crop.

THE HABITABILITLY OF A COUNTRY DEPENDS ON ITS WATER SUPPLY.

Ignoring for the moment the possibilities of crop production in an arid country, the desirability of such a country as a human habitation is contingent on its water supply. Urban life demands the provision of abundant supplies of good water. The isolated settler seeks out a spring or stream beside which to make his home. Even the wayfarer finds a supply of water before making his camp for a single night.

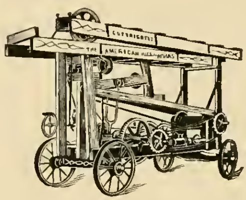


Fig. 4. H. P. WELL DRILL.
(Courtesy American Well Works, Aurora, Ill.)

The farmer must provide water for himself and his family. His animals cannot live without it. His first consideration is its supply. If there is no good spring or stream and a well fails to afford this necessity, permanent habitation is impossible.

Soils are now being tilled in the arid regions where water supplies do not permit settlement, and only temporary camps are feasible. In such cases water is hauled, sometimes for miles, for use of men, teams and engines to till the land.

NATURE AND SOURCE OF WATER.

Chemically water is a compound of two gaseous elements, hydrogen and oxygen with the formula (H_2O).

Physically it is a colorless, transparent, tasteless liquid. While both its component elements exist free in nature, the presence of free oxygen being an essential condition of life, water is itself one of the most abundant substances in nature. Practically three-fourths of the earth's surface is covered with water. Its depth is often several miles. The atmosphere is always more or less charged and frequently saturated with its vapor.

Land areas all carry lakes and rivers. The earth is moist and often wet with the rain that descends upon it. There is, perhaps, no land area where standing water does not exist at a greater or less depth below the surface, and generally within a few feet.

It is constantly evaporating from the surface of land and sea, carried off in the air, condensing into clouds, precipitating as rain or snow, sinking into the earth, emerging again in springs, forming in rills, uniting into streams, which converge into rivers and flow again to the sea. Thus the cycle of its activity is completed and repeated from the dawn of time until eternity.

OCCURRENCE AND FUNCTION OF WATER.

The universality of the occurrence of water as such has been noted. It should be further observed that it enters into the chemical composition of a large portion of the substances found in nature which chemists have resolved into their component parts. No other substance appears to be so universally associated with every material thing. Most of the minerals of the earth are crystalized with a certain proportion of water. Rocks and soils are therefore formed partially of it. All living organisms, as has been noted, are largely made up of water. Water combined with another gas, carbon, forms the food of animals and the raiment and shelter for man. Sugar, starch and cellulose are the simple combinations of water and carbon. Cellulose makes up the cotton and linen for our apparel and the wood for our houses.

Water is associated with most objects by contact or adhesion, as well as in combination, and in this relation the earth and its plant and animal life find it indispensable.

Water in soils is divided into three kinds, according to the condition in which it occurs as stated by King. *

I. Hydrostatic, free or gravitational water is "that which fills the pore spaces between the soil grains, and is free to move under gravitational or hydrostatic pressure."

II. Capillary water is "that which adheres to the surfaces of soil grains and to the roots of plants in films thick enough to allow surface tension to move it from place to place."

III. Hygroscopic water is "that still retained on the surface

*Physics of Agriculture. p. 151.

of soils when they become air dry; whose chief movements are those of evaporation and condensation."

In addition to these three conditions of soil moisture is the water of composition that is only discovered by resolving mineral compounds into their component parts.

Hydrostatic or gravitational water is not directly useful to plants, and soils are not generally productive when it stands too near the surface. It may, however, be the reservoir from which the capillary water is drawn. Drainage is resorted to to rid the soil of this objectionable standing water, for it excludes the air, suffocating plant roots and useful microorganisms. It injures the texture of soils by puddling, and it washes out soluble plant food.

It is chiefly from the capillary water in soils that plants derive their supplies. Under perfect conditions each soil particle is surrounded by a film of moisture which does not fill the pores, but keeps the particles moist and moves towards the places where its amount is reduced. Generally it moves upward to replace that lost by evaporation. Capillary water dissolves and holds plant food for the nourishment of plant roots; but under normal conditions of soil texture does not exclude the air from the interstices, nor interfere with the action of bacteria.

Hygroscopic water is probably not available for the support of vegetation.

WATER CAPACITY OF SOILS.

The maximum capacity of soils for water is measured by the amount of pore space between the soil grains. It has been computed that this ranges between 35 and 53 per cent of the volume. Coarse sands have the least and fine clays the greatest aggregate space between the grains of a given cubic amount. About 40 to 45 per cent of a good loam is occupied by air.

Under ordinary soil conditions the force of gravity removes the hydrostatic or standing water to lower levels by drainage, leaving only the capillary water which is held by the force of adhesion or surface tension. It is the capacity of soils for capillary water that is of real agricultural significance. Here again the capacity is in inverse ratio to the size of the grains.

It has been computed that the soil grains present the following amounts of surface per cubic foot: (King's Agr'l Physics.)

Coarse sands	8,000 square feet.
Sandy loam	37,000 square feet.
Loam	45,000 square feet.
Clay loam	60,000 square feet.
Heavy clay....	90,000 square feet.
Finest clay	175,000 square feet.

Inasmuch as the capillary water is held in the form of a film around each soil grain, the amount of surface presented directly determines the capacity for water, under perfect conditions.

The capacity for water is greatest in humus soils, and least in sandy soils. It is greatest in the surface foot and gradually diminishes downwards. The greater the distance to the water table or standing water the less the capillary power.

A rough estimate of the capacity of soils to hold water under average conditions in the first four feet in depth, might be twenty-five to thirty per cent of its volume, equal to from twelve to fifteen inches of rainfall. In many Montana soils it is probable that the percentage capacity would remain very little diminished to much greater depths on account of the absence of subsoil and hardpan.

Movements of water in soils are two: The first a downward movement, occasioned by the force of gravity, tends to rid the soil of superfluous water by drainage, and while necessary in humid climates it is the occasion of some loss of soluble plant food. In the arid regions, without irrigation, this movement may be disregarded.

The second or capillary movement is caused by the physical force of surface tension or capillarity, where each drop attracts and draws to itself other drops in the zone of its influence. It is the force which causes oil to rise in the wick, or water to run over the edge of a basin through a wet towel. Practically this movement is upwards in soils because of the attraction of the water which is being transpired by plants or dispersed in the air by evaporation. Water is constantly drawn upward to replace that which has gone off in vapor. Capillarity is most active when the soil is moist and on a perfectly dry surface rains will often run off without wetting the soil to any great depth.

EFFECT OF WATER ON SOIL FERTILITY.

1st. Water is in itself plant food and is essential to organic life.

2nd. Water is the solvent of mineral elements in the soil which go to nourish the plant, and without it this solution does not take place. Plants are capable of absorbing mineral salts only in a water solution.

3rd. It furnishes the condition essential to the development of bacteria. Many important changes in soil compounds and many chemical processes of value to vegetation, are brought about by bacterial action, or fermentation. These organisms are active only under favorable conditions of moisture. The formation of nitrates is an example of this class of activities.

4th. The mechanical action of water under the force of gravity in eroding rock surfaces, and grinding rock fragments in soil formation.

5th. The action of water in conjunction with temperature changes. As it penetrates the interstices of the rock and pores of soil, and expands in freezing it overcomes cohesion, and disintegrates the mass, producing a condition of texture more favorable to plant growth.

WATER IN RELATION TO PLANTS.

The importance of moisture to vegetation is suggested by the degree in which it enters into the composition of growing plants. Water is found in growing crops to the following extent:*

Timothy, red top and millets	80 per cent.
Orchard grass	70 per cent
Oats, barley and rye	75 per cent.
Alfalfa and clovers	80 per cent
Peas (Canada) and vetches	85 per cent
Rape	85 per cent
Sorghum	80 per cent
Apples	78 per cent
Sugar beets	84 per cent
Mangolds	89 per cent
Turnips and cabbage	90 per cent
Potatoes	80 per cent

*Hatch (Mass.) Experiment Station Report, 1905.

Even the dried crops contain still a considerable percentage of water.

Hays contain	15 per cent
Wheat flour	11 per cent
Wheat bran and middlings	10 per cent
Corn (maize grain)	11 per cent
Oats	11 per cent
Wheat	11 per cent
Speltz (emmer)	8 per cent

In the light of the foregoing it is safe to say that from 75 to 90 per cent of the fresh substance of farm crops is water, and it even forms ten or fifteen per cent of their air dry substance.

The moisture content of a plant is no gauge of the amount of water necessary for its development. Careful and extended observations in this country and in Europe have shown that hundreds of tons of water are used for every ton of dry vegetable matter produced.

The following taken from King's Physics of Agriculture shows the amounts of water lost from the soil by evaporation and transpiration during the growing season in Wisconsin:

	Water per ton of dry crop...	Total water used. Inches.	Dry Crop per acre tons	Acre-inches of water per ton of dry crop....
Barley	464.1	20.69	5.05	4.1
Oats	503.9	39.53	8.89	4.4
Maize	270.9	15.76	6.59	2.4
Clover	576.6	22.34	4.39	5.1
Peas	477.2	16.89	4.01	4.2
Potatoes	385.1	23.78	7.00	3.4

Here is a range for each ton of dry substance produced of from 270 tons or 2.4 acre-inches in maize to 576 tons or 5.1 acre-inches in clover.

Hellriegel, in Germany, observed that wheat used about 453 tons, or 4 acre-inches for every ton of dry matter produced. F. Haberlandt, in Germany, computed that one acre of oats transpired through the tissues of the plants 99 tons of water, and one acre of

barley 54 tons. The yields are not stated. He further observed that a single maize plant transpired 30.8 pounds of water during its development from seed to maturity, which would be equivalent to about 150 tons per acre for an average crop.

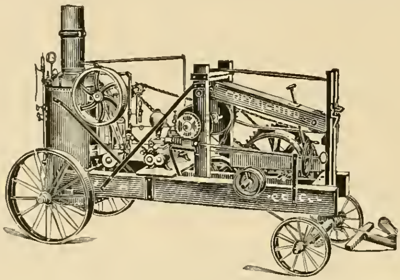


Fig. 5. STEAM WELL DRILL.
(Courtesy American Well Works, Aurora, Ill.)

At the Rothamsted station in England it was observed that six hundred and fifteen tons of water was taken to produce two and one half tons of grain.

Probably on the average not less than three hundred tons of water is used for every ton of dry substance in the crop.

According to Hellriegel's observation the following amounts of water will be required to produce the adjacent crop yields on the basis of one and one-half tons of straw to one ton of grain.

15 bushels of wheat and its straw require 4½ acre-inches.
20 bushels of wheat and its straw require 6 acre-inches.
25 bushels of wheat and its straw require 7½ acre-inches.
30 bushels of wheat and its straw require 9 acre-inches.
40 bushels of wheat and its straw require 12 acre-inches.

Probably Montana grains are somewhat heavier in proportion to straw than the average, although this may be in part due to the practice of leaving a high stubble which requires as much water to produce as other parts of the plant.

Records of the Montana Experiment Station show the following ratio of grain to straw:

Wheat....3:4. Oats....2:3. Barley....6:7.

The different kinds of barley have given the following ratios of grain to straw:

Hulless....1:1. Two rowed....3:4. Six rowed....5:6.

The following table shows a computation of possible yields of various crops under given amounts of available water expressed in acre inches.. It must be understood that this will hold only when there are no losses by drainage or undue evaporation.

Acre-inches of water	4	6	8	10	12
Wheat bushels	13.3	20.0	25.7	33.3	40.0
Barley bushels	19.0	28.5	38.0	47.5	57.0
Maize bushels	25.0	37.5	50.0	62.5	75.0
Oats bushels	26.7	40.0	53.0	66.7	80.0
Potatoes bushels	200.0	300.0	400.0	500.0	600.0
Clover hay tons	1.	1.5	2.	2.5	3.

Not all the water held by the soil is available to the crop. A certain percentage is held by the soil grains with a tenacity too great for plant roots to overcome. Soils differ in respect to the percentages of water which they retain after plants cease to grow. In a clay loam plant growth ceases when there is yet seven or eight per cent moisture in the surface soil, while all but three or four per cent of the moisture in a sandy soil may be available. A humus soil will hold a still larger percentage of water after plant growth stops.

To secure the best growth a clay loam subsoil should contain from 15 to 25 per cent of water in the top four feet.

FUNCTIONS OF WATER IN PLANT GROWTH.

1. It is of itself a plant food. Inasmuch as at least three-fourths of the fresh substance of plants is water, it is an essential component substance.

2. Its solvent action on plant food. By immersing each soil particle in a thin film of water a part of its soluble matter is extracted and passes into solution in the soil water. Plant roots are capable of taking up their mineral food substances only in water solutions.

3. Its transporting and distributing agency. By the principle of diffusion of bodies in solution, water brings to the root hairs the food substances it contains. It also continues its transporting and

distributing function in the tissues of the plant after being absorbed with its dissolved matters.

4. It maintains a proper physical condition in plants. By it the breathing pores are kept moist and the plant cells maintained in a proper state of turgidity. Without water plants wilt, wither and die, and their substance dries up. The temperature of plants is regulated by evaporation.

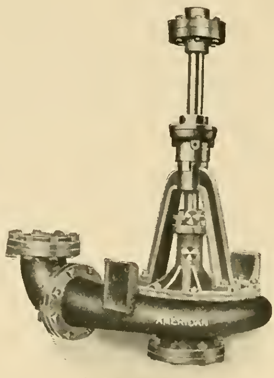


Fig. 6. VERTICAL PUMP.
(Courtesy American Well Works, Aurora, Ill.)

WATER IN RELATION TO DOMESTIC ANIMALS.

Water is everywhere recognized as essential to animal life. It is not unlikely that all land animals have been evolved during the ages from aquatic ancestral species. None of our domesticated animals are able to subsist without water for any considerable period of time. Daily supplies are recognized as of equal importance to the dry food.

When we consider that about sixty per cent of the animal live weight is water, its need becomes at once apparent. The range of water in animals is between forty and seventy-five per cent of the live weight. The per cent is less in very fat full aged animals, and greater in those that are young or lean.

While a two-year-old steer weighing one thousand pounds may contain about six hundred pounds of water, he will have consumed from twenty to thirty thousand pounds in producing his thousand pounds of live weight or four hundred pounds of dry substance.

From fifty to seventy-five pounds of water is consumed for every pound of dry flesh produced.

Georgeson found that steers drank from forty-seven to ninety-one pounds of water daily. (Kansas Bulletins 34 and 39.)

Emery recorded a daily consumption averaging fifty-six pounds of water for every thousand pounds live weight. (North Carolina Bulletin 93.)

This large consumption of clear water in addition to the considerable amounts contained in the solid food eaten, appears to be necessary to the proper functional activities of the animal. A considerable exhalation of vapor from the lungs and through the pores of the skin is constantly going on in addition to the discharge in the sensible excretory products.

Water performs an important function in maintaining the temperature of the body. Heat above normal is very rapidly absorbed by the increased evaporation of water.

In the circulation of the blood it is necessary that its fluidity be maintained by a large percentage of moisture.

Digestion and resorption are active only when the juices are sufficiently abundant to carry the digestive fluids and transport nutrients in solution.

Deprived of water serious derangements of functional activities arise; and in many disorders the need and craving for water is a noticeable symptom.

RELATION OF WATER TO CROP PRODUCTION.

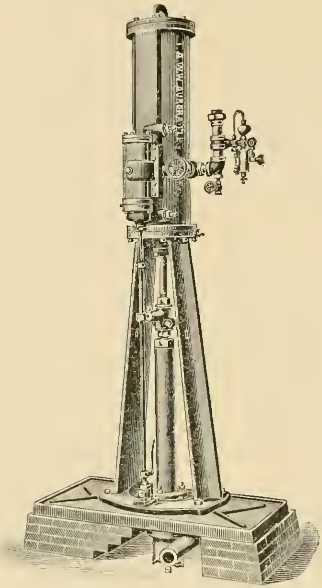
It has been observed that water is indispensable to vegetation. There is a degree of moisture more favorable to plant development than either an excess or a shortage.

We have learned that less than fifteen per cent of moisture in average soils will pinch the crop, and that growth commonly ceases when it falls below eight per cent.

On the other hand, it has been found that when the soil pores are completely filled with water to the exclusion of air, or the ground becomes water logged, a condition that comes when from thirty-five to fifty per cent of the volume of soils is water, (according to the kind of soil) vegetation languishes and crops do not thrive.

About twenty to twenty-five per cent is the most favorable pro-

portion of soil moisture for ordinary crops. This means ten or twelve inches in the top four feet of soil. To maintain this is the farmer's problem. Drainage is desirable when moisture is present in excessive amounts. Conservation by proper tillage or irrigation are measures to correct the opposite tendency.



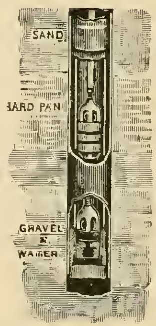


Fig. 7. DEEP WELL PUMP HEAD. Fig. 8. WELL CYLINDER.
(Courtesy American Well Works, Aurora, Ill.)

EFFECT OF WATER ON LAND VALUE.

When the settler fences in and acquires the right to the only spring or water supply of a range the value of the adjacent pasture to other parties is lost.

In the main, while water is not the only factor in determining land values, its absolute necessity makes it a very safe criterion. In humid countries where all land has an adequate supply of moisture, its effect on value is largely ignored; but in an arid region the question of water rights becomes almost the first to be considered.

Without artificial water privileges land must be rated very largely according to its natural supplies, and the possibilities of conserving these for purposes of crop production.

CHAPTER III.

CONSERVATION OF MOISTURE.

In its definition this involves the presence of water in greater or less amounts, and its retention for useful service in crop production. Conservation of moisture means the reduction of losses to a minimum in order that the largest possible percentage may be utilized in plant growth.

The apparent sources of water on dry farms are the natural precipitation on the area in question and the surface drainage from higher lands. The former is fixed by nature and not subject to man's control, the latter is worthy of attention as a possible increase in valuable farm resources.

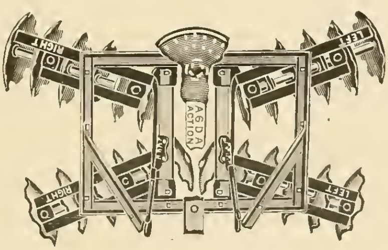


Fig. 9. DOUBLE ACTION CUTAWAY HARROW.
(Courtesy of Cutaway Harrow Co., Higganum, Conn.)

PREVENTION OF WASTE.

It has been observed that water moves in the soil by gravity and by capillarity. It becomes apparent that in preventing escape the two doorways, drainage and evaporation, should be considered.

Sub-drainage is probably not active in arid lands. Surface drainage may occasion some loss where heavy rains fall on a hard smooth surface. The obvious remedy is to break the surface in such a way that any precipitation will be retained until it can percolate into the soil. Leaving tall stubble to prevent snow blowing off in winter is another preventive.

Evaporation is by far the most serious source of loss of soil moisture. By capillary attraction water rises through the pores to the surface of the soil, as through fine capillary tubes, or as oil in the lamp wick. The hot sun and drying winds quickly vaporize surface moisture, strengthening the force which draws water from below.

Professor King of Wisconsin found that one pound of water per day was evaporated from a square foot of soil surface when the capillary water had to be drawn through a depth of four feet of earth. At this rate during 200 days of the year when evaporation is most active there would be 200 pounds of water lost from every square foot of surface. Allowing 62½ pounds per cubic foot, this would mean 38.4 inches of water.

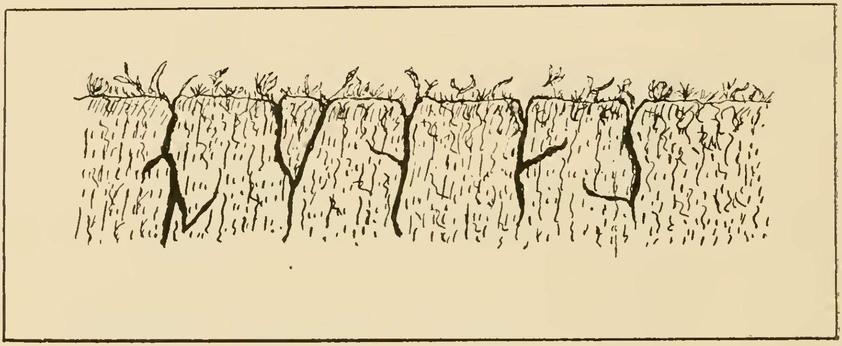


Fig. 10. SHOWS CRACKS IN UNTILLED GROUND.

Prof. S. Fortier at the Montana Experiment Station, conducted experiments in 1901 to note the amount of water lost from a soil surface two and one-half feet above water level, and between May 23 and Sept. 1, a period of 100 days, observed a loss of 28.7 inches from a cropped soil and 13.5 inches from a bare soil. The development of plants on the former appeared to have increased the loss 14.2 inches by transpiration.

Between Sept. 1 and Dec. 1, an evaporation amounting to 2.4 inches took place on an untilled stubble.

The evaporation observed at the Montana Station from a soil surface, well supplied with capillary water was:

41.6 inches May —Oct. 1, in 1900.
52.8 inches Apr. 1—Oct. 1, in 1901.
48.2 inches Apr. 1—Oct. 1, in 1902.

It becomes evident that evaporation may easily exhaust the rainfall, and that practical conservation of moisture lies chiefly in checking evaporation from the soil surface.

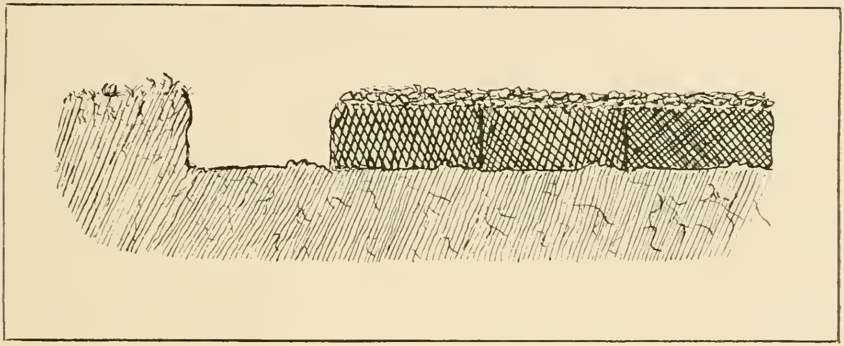


Fig. 11. FLAT BREAK, ROLLED DOWN.

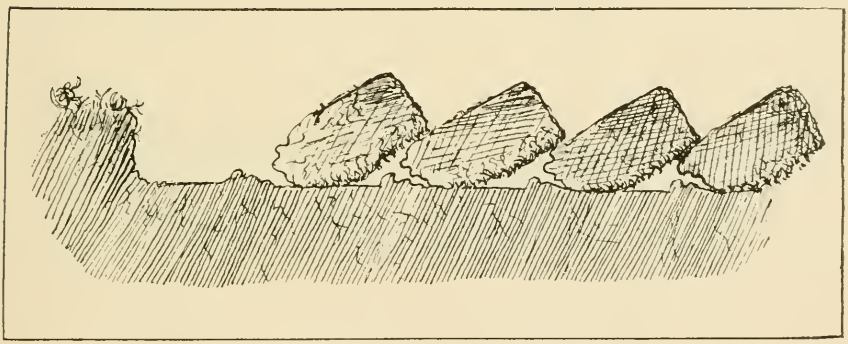


Fig. 12. ORDINARY TILLED BREAK.

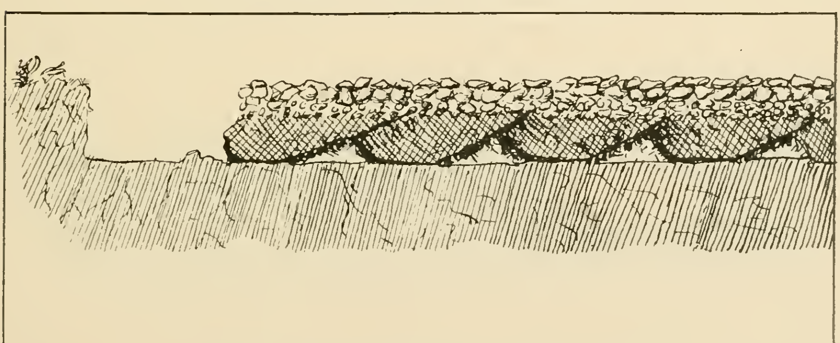


Fig.13. TILLED BREAK, HARROWED.

METHOD OF CHECKING LOSS BY EVAPORATION.

This consists first in plowing the ground, cutting off the capillary tubes below the surface. As plowing may not cover the moist subsoil completely with loose earth, harrowing should immediately follow to reduce the amount of surface exposed to the air, to cover the subsoil and to form an earth mulch. Immediately, in this connection, may be taken to mean the same half day before the team leaves the field.

Secondly, conservation of moisture requires a maintenance of the earth mulch by frequent harrowings. The good judgment of the farmer will have to serve as a guide to the frequency of harrowing. In a general way this should be often enough to overcome the tendency of capillary moisture to come to the surface. As rains serve to re-establish capillary action of the surface soil, harrowing should follow rains as soon as the ground is workable.

Never allow a crust to form or let the top three or four inches become packed together.

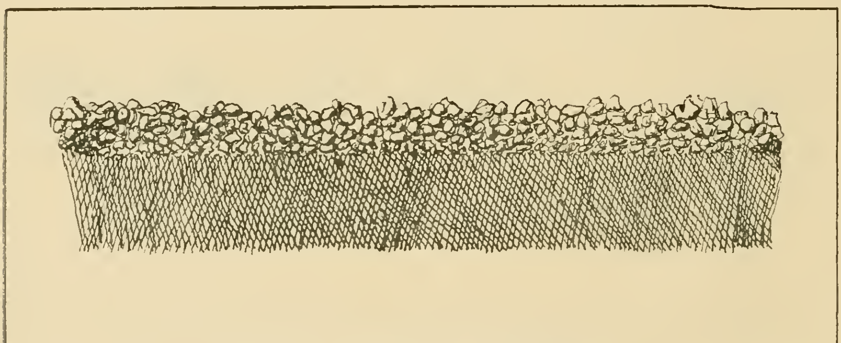


Fig. 14. HARROWED GROUND.

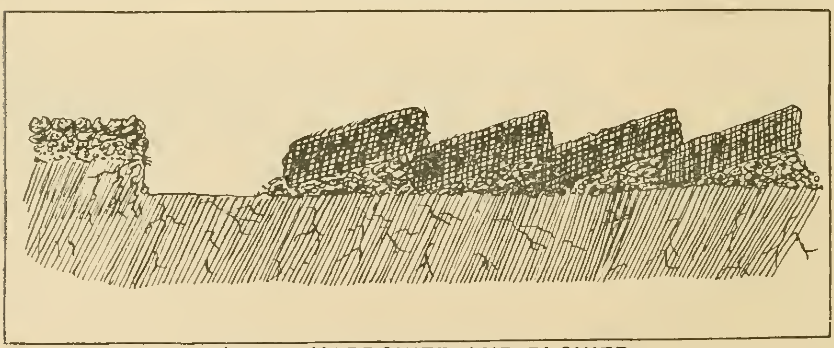


Fig. 15. HARROWED AND PLOWED.

CHAPTER IV.

MOISTURE CONTROL.

By H. O. BUCKMAN.

In farming the dry table lands of Montana where irrigation water can not be economically obtained, some understanding of soil physics is necessary. How to plow, how to cultivate and how to seed so that the moisture can be utilized and retained in the largest amounts is the question. In studying a problem of this kind we shall properly put aside for the present all consideration of plant food and crop returns or rather we shall assume for convenience that ordinary methods for conserving moisture tend to convert more plant food into a soluble form. In fact, this supposition is really a correct one as we readily learn from examining the work of such men as King, Hilgard and Lawes. Lately German investigators have found that "the crop yield as well as the absorption of plant food uniformly increases with the water content of the soil." We will at this time merely outline the system and show the results obtained in terms of moisture or inches of rainfall. Quoting then from Bulletin 63 of the Montana Experiment Station, the following points are to be observed in handling the soil from an arid land standpoint:

1. Formation of a deep seed bed as a moisture reservoir.
2. Summer tillage to hold moisture.
3. Formation of a dust mulch.
4. Fall plowing where practicable.

Both increased crop yields and moisture determinations show that these general methods conserve water. However, the real question remains as to how much water is present at stated intervals during the season. What we need is a continuous moisture record of a piece of ground under a certain method during the entire season. To know the per cent of water in the soil at one particular time is not enough as only conclusive statements can be deduced from continuous and consecutive data. However, it is to be regretted that such data is not now available, and only partial and fragmental records can be offered, which, while not completely covering the ground, may give some indication of the truths we seek.

A DEEP SEED BED.

The texture of a soil has direct reference to the size of the particles which give it its structural characteristics. That is, it is made up of granules which are large or small, single or compound in accordance with the type of soil, its humus content, or its previous treatment. It is said that a soil is in good tilth when it is neither too fine nor too coarse, and when the particles are not too firmly cemented together. In other words, good tilth represents a condition which offers the best facilities for plant growth. It is quite apparent, moreover, that when the soil is granular a considerable space is left for air circulation and water conservation, and in an arid country the problem is to obtain the happy medium where the largest water supply can be maintained with the minimum loss of moisture.

Consequently we can readily anticipate what the effect of deep plowing must be, for it not only loosens up more soil and makes it suitable for root penetration, but it increases the capillarity of the soil in question. Prof. King of Wisconsin offers some interesting data along this line. Two pieces of ground were taken, side by side, and one plowed at ordinary depths while the other was stirred and loosened to twelve or fifteen inches below the surface. They were then treated with the same amount of water and the surfaces covered to prevent evaporation. The object was to determine the retentive power of the two plots under the different treatments.

CAPILLARY POWER OF SUBSOILED GROUND

	Subsoiled Lbs.	Not Subsoiled Lbs.
First foot gained	124.60	102.10
Second foot gained	72.57	10.34
Third foot gained	38.22	12.05
Fourth foot gained	33.26	3.82
Fifth foot lost	2.29	19.50
Total water gained	268.65	128.31
Total water added	254.41	254.41
Difference in lbs.	14.24	126.10

King found that deep tillage besides increasing the absolute water capacity also enabled the soil to maintain and even increase

its store of moisture when compared with plots not so treated. The moisture data given below was taken seventy-five days after the plowing of the two plots took place, when the moisture content of each was the same.

RELATIVE MOISTURE CONSERVED BY DEEP AND SHALLOW PLOWING.

	Subsoiled Percent	Not Subsoiled Percent
First foot	17.07	18.91
Second foot	23.29	19.42
Third foot	22.76	17.78
Fourth foot	16.36	14.19
Fifth foot	18.14	19.20
Average	19.52	17.90

The significance of this table will become more apparent when the per-cents of moisture are interpreted into pounds of water per acre-foot. One per-cent is equivalent to .18 inches of rainfall while an inch of rain means 225,750 lbs. of water. Then with a difference, in every one of these five feet of soil under consideration, of 1.72 per-cent, we have an equivalent of .31 inches of rainfall, or 69,927 pounds of water or a total in the five feet of 1.55 inches of water or 349,860 pounds. It is generally conceded that it takes about 450 pounds of water to produce a pound of dry matter with wheat. Then for a 20 bushel crop, the amount of actual available water must be about a million and a half pounds per acre. Consequently it may be easily seen that this 350,000 pounds more or less of water saved by deep plowing might decide whether the dry land farmer would just manage to subsist through the winter or live in plenty with a bank account as a comfortable margin.

The rational deduction is that subsoiling must decrease capillary action as we find that it tends to conserve moisture. The one objection is the heavy labor of such tillage, but that is overruled by other considerations. Deep plowing, then, has several distinct advantages which cannot be overlooked by the dry land farmer. These advantages in short are:

1. An increased capillary capacity of the soil for water.
2. A better tilth to a greater depth.
3. A deep seed bed for crop root development.
4. A decreased loss by surface evaporation.
5. Increased gravitational capactity for conducting water.

SUMMER TILLAGE.

In a semi-arid country where the rainfall is fifteen inches or less it can be readily seen that even if it came wholly in the growing season, the precipitation would barely be sufficient for a paying crop. However as only a little over half of it falls between March and July some method of systematic conservation must be practiced.

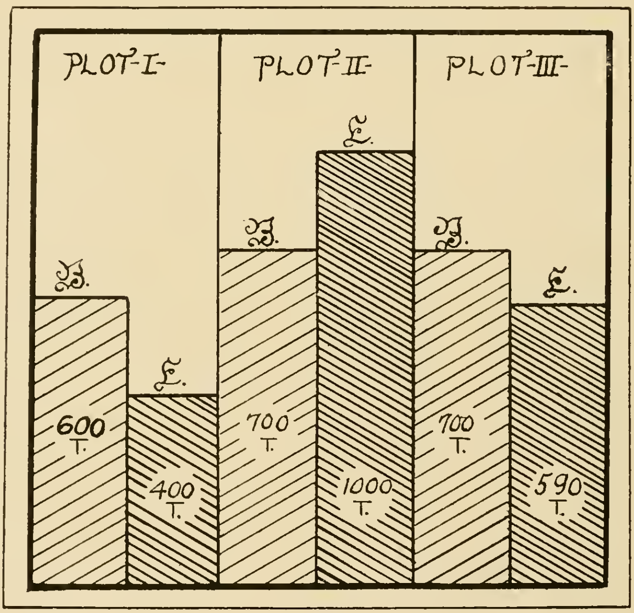


Fig. 16. DIAGRAM SHOWING RELATIVE AMOUNTS OF WATER AT BEGINNING AND CLOSE OF SEASON.

Plot I. Continuous crops.
Plot II. Fallow cultivated.
Plot III. Fallow uncultivated.

Summer tillage, although of no especial use in the states of the middle west, seems here to be an absolute benefit, not only from the conservation of moisture but in the solution of plant food. At the Montana Experiment Station, samples were taken on two adjoining plots at the close of the season of '07, one cropped continuously and the other alternately cropped and summer tilled.

MOISTURE CONTENT OF CONTINUOUS CROPPED AND FALLOW SOIL.

Date	Plot	1st ft. Per ct.	2nd ft. Per ct.	3rd ft. Per ct.	4th ft. Per ct.
Oct. 19	—Continuous crop............	8.40	6.75	6.47	7.20
Oct. 19	—Summer tilled................	16.37	16.87	14.51	15.92

In the case of continuous cropping we have at the end of the season an average of 7.21 per cent moisture. This is equivalent to 838,162 pounds of water an acre to a depth of three feet. Of this, however, only 256,912 pounds are available. This is a very small store of moisture to begin the growing of even ten bushels of wheat. On the other hand the fallow ground contains an average of 15.92 per cent of moisture or 1,849,537 pounds of water in an acre to the depth of three feet. This represents 1,238,287 pounds that are available or about five times more than in the continuously cropped plot.

Moreover, the plot continuously cropped appeared dry throughout a greater part of the season below the depth of three feet, while the summer tilled soil had an average of 13.68 per cent of water for a depth of six feet on Oct. 19. This would be equal to a total of 14.77 inches of rainfall against 5 inches in the continuously cropped ground. When we learn that only the moisture above 5 per cent is available these figures become doubly startling. Consequently the assertion that we can store from ten to twelve inches of rainfall by summer tillage is very conservative indeed. Adding this to the rainfall of the next year's growing season we have a very respectable moisture supply. King found that a sandy loam not fallowed lost 6.05 inches of water per acre in one hundred days, while one cultivated lost only half that amount. The reasons, then, for the great difference in the foregoing figures become apparent.

Hilgard of California from observations on two plots, side by side, came to the same conclusion as to the results of summer fallowing. His table given below serves to impress only the more

strongly the benefits of such a soil treatment from a standpoint of moisture control alone. The data is as follows and needs, I think, no comment.

THE EFFECT OF SUMMER TILLAGE ON RETENTION OF WATER.

Depth of Soil Samples.	Cultivated		Uncultivated	
	Water percent	Tons per acre	Water percent	Tons per acre
First foot	6.4	128	4.3	86
Second foot	5.8	116	4.4	88
Third foot	6.4	128	3.9	78
Fourth foot	6.5	130	5.1	102
Fifth foot	6.7	134	3.4	69
Sixth foot	6.0	120	4.0	90
Total for six feet	6.3	756	4.2	512

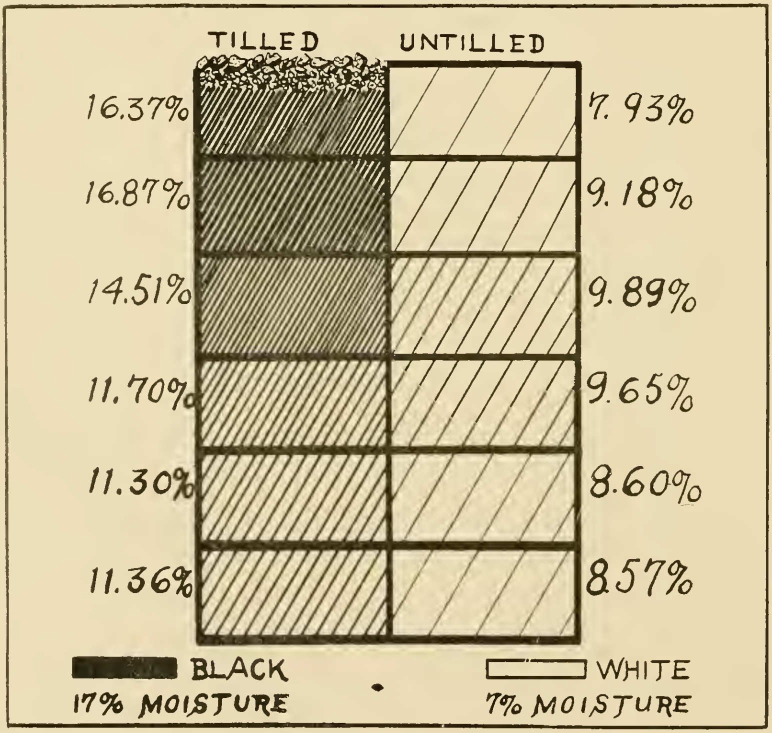


Fig. 17. DIAGRAM SHOWING THE EFFECT OF SUMMER TILLAGE ON PER CENT OF MOISTURE IN THE TOP SIX FEET OF SOIL.

DUST MULCH.

In consideration of the principles of fallowing we can not pass over the importance of maintaining a dust mulch. In the season of '07, samples were taken on two adjoining plots at the Montana Experiment Station, one having received cultivation throughout the summer and the other untilled. On Oct. 19 the following percentages of moisture were found:

MOISTURE CONTENT AS AFFECTED BY DUST MULCH.

Plot	1st ft.	2d ft.	3d ft.	4h ft	5th ft	6th ft.
Percent water in mulched plot........	16.37	16.87	14.51	11.70	11.30	11.36
Percent water in unmulched plot......	7.93	9.18	9.89	9.65	8.60	8.57

It is only fair to state that the unmulched plot maintained its moisture till the dry season set in, but that makes little difference as it is the whole season's result that is important. These figures mean that the mulched plot had stored in the first three feet 8.5 inches of rainfall while the other had only 5.5 inches. What the effect of this will be on the next year's crop is not hard to estimate.

When a moist soil is cultivated for the formation of a dust mulch the immediate effect is rapid evaporation, but this loss is mainly from the stirred soil and is a sacrifice for future saving. When this upper soil layer has once dried it allows water to pass through it very slowly. The principle is the same as that operating in the reluctance of a dry sponge to absorb moisture. King carried on some work with dust mulches and besides demonstrating their practicability he found that a three-inch mulch was the most economical moisture saver. The test ran one hundred days and the moisture lost, expressed in inches of rainfall, is shown in the following table.

SOIL MULCHES.

Kind of Soil	No mulch....	1-in. mulch....	2-in. mulch...	3-in. mulch....	4-in mulch....
	Ins.	Ins.	Ins.	Ins.	Ins.
Sandy loam lost.....	6.54	3.30	2.99	2.53	2.78
Black marsh soil	5.19	3.12	2.38	2.26	2.23
Virgin clay	21.31	11.13	8.65	7.85	7.80

CONSERVATION OF MOISTURE BY DUST MULCH.

Depth of Soil	No Mulch	Mulch
	Percent of Water	Per cent of Water
First foot	4.3	6.4
Second foot	4.4	5.8
Third foot	3.8	6.4
Fourth foot	5.1	6.5
Fifth foot	3.4	6.7
Sixth foot	4.5	6.0
Average for six feet	4.2	6.3

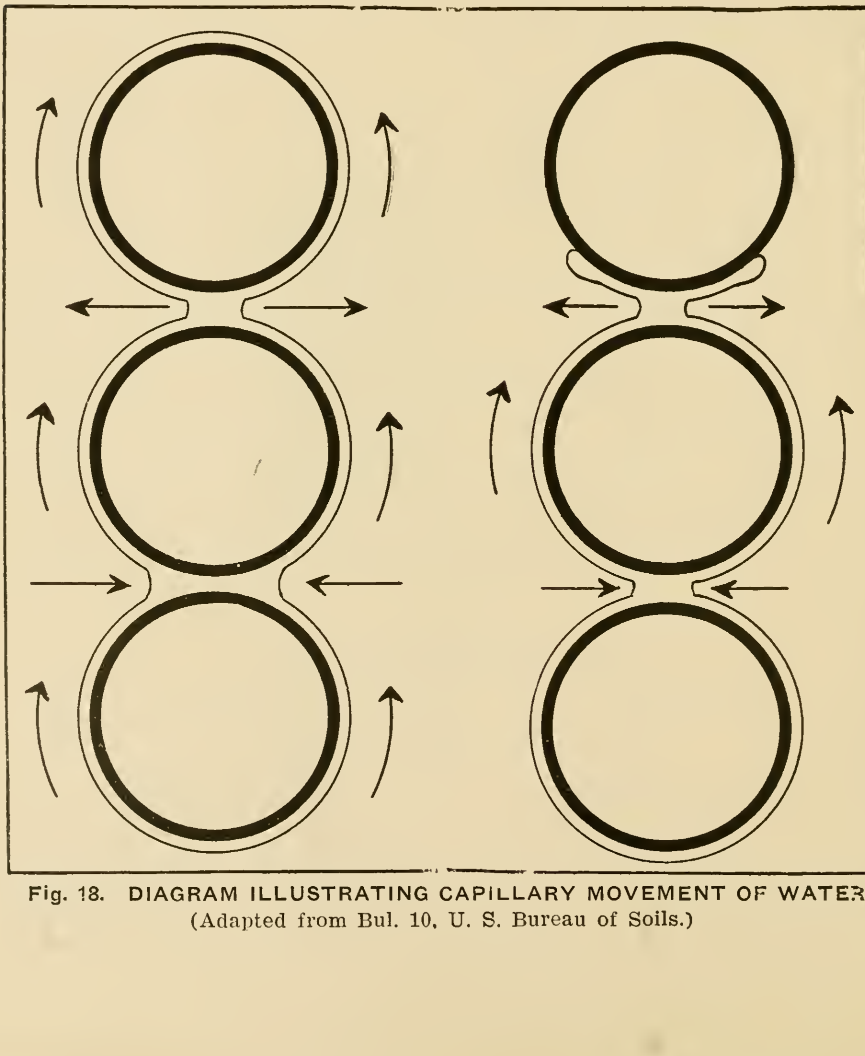


Fig. 18. DIAGRAM ILLUSTRATING CAPILLARY MOVEMENT OF WATER.
(Adapted from Bul. 10, U. S. Bureau of Soils.)

I cannot resist offering for study the above table showing the moisture conditions in a soil having no dust mulch and one so supplied. The data comes this time from near Niles, California, and is published by Hilgard, one of the most noted soil authorities of the United States.

The dry land farmer should then establish a dust mulch wherever it is practicable on his land and maintain it by harrowing after every shower and at such other times as it becomes necessary. The effectiveness of the mulch depends on the size of the soil grains, the coarseness of the structure, thickness of mulch and the frequency of cultivation.

FALL PLOWING.

In a discussion of fall plowing as a method of conserving moisture we take up a question which is the subject of much discussion. We would expect from the preceding tables that, when all other conditions are equal, fall plowing tends to conserve moisture. King says that in arid lands where the soil is light and there is no danger of losing plant food by leaching, fall plowing is a valuable means of conserving and storing moisture. This view agrees with all data that we now have except under one condition.

In a country where the snow of the winter is liable to blow, stubble land is much better left unplowed. This is because the standing straw catches the snow and has been known in Montana to add two percent more moisture to the soil over that found in an adjoining fall plowed plot. In general, fall plowing is to be encouraged as the data from the Utah Experiment Station shows.

TABLE SHOWING EFFECT OF FALL AND SPRING PLOWING ON SOIL MOISTURE.

Depth of Sampling.	Fall plowed.	Spring Plowed.
Per cent of water in 1st ft...........	18.07 per cent	18.49 per cent
Per cent of water in 2nd ft ...	24.69 per cent	20.41 per cent
Per cent of water in 3rd ft..........	22.18 per cent	19.55 per cent
Per cent of water in 4th ft..........	33.90 per cent	23.24 per cent
Per cent of water in 6th ft.	40.90 per cent	29.28 per cent
Total inches of water	53.54	46.87

Ground plowed in the fall really acts as a dust mulch during the winter and early spring. This is especially important in Montana

where the early part of the spring is liable to be rainless and the winds dry and strong. Moreover, the roughened surface would tend to catch snow more or less and the loosened soil would offer easier penetration for the rain and snow water. In Wisconsin even on as late a date as the middle of May, fall plowing was found to contain 6 lbs. more of water per square foot for the upper four feet than an adjacent plot not so treated. Now conceding that fall plowing is not a practical proposition the only alternative is in as early spring plowing as possible. The arguments for early spring plowing are the same as we have advanced for fall plowing. In the spring the soil is usually comparatively moist and the loss of moisture from such a soil is liable to be large. Plowing followed by cultivation breaks the capillarity and reduces evaporation to a minimum. Besides this the improved physical condition due to fall plowing is no slight factor, especially its effect on the liberation of plant food.

In actual figures Prof. King found that, in two plots plowed in the spring seven days apart, there had been no loss of moisture from the earlier plowed soil, while the later plowed plot had lost in the surface four feet of soil an amount equivalent to 1.75 inches of rainfall. Besides this the late plowed plot had deteriorated considerably in physical condition; so much so that more work was necessary to fit it for seeding and even then it was much inferior in tilth to the earlier plowed plot.

After such a discussion it seems hardly necessary to offer any summary. As moisture is the factor in arid land cultivation, all energies must be bent towards its conservation. Deep plowing, summer tillage, dust mulches and alternate cropping appear to be productive of the best results.

DRY FARMING RHYMELETS.

They're digging for wells on that flat up there,
  Where its drier than all get out—
And the water they get won't wet their hair,
  And pretty soon they'll find it out.

They may plow and harrow and disc it, too,
  With their fool dry farming schemes—
But I'll bet my head against an old shoe,
  Their crops will be mostly dreams.
—From the Terry Tribune. As an "old timer" sees it.

CHAPTER V.

TILLAGE AND TILLAGE IMPLEMENTS.

OBJECTS.

It is a fact that has been well known by practical farmers for ages that stirring the soil increases its producing capacity. The art of tillage has been practiced for thousands of years, and the study of methods and means of securing the best results in soil manipulation has received a vast amount of attention throughout the period of human history. Nevertheless we find ourselves taking up the discussion in its application to semi-arid lands with much hesitation and uncertainty.

The great object of tillage is to put the soil in the condition most favorable to plant growth. A **good tilth** implies the proper degree of openness for the development of soil organisms and the movement of air and moisture. We might state more particularly that the objects of tillage are:

1. To form a suitable seed bed.
2. To remove organic matter from the surface.
3. To regulate soil moisture and air.

The Seed Bed should be favorable to the germination of seeds and the best subsequent development of plants. The essentials of germination are a suitable degree of moisture, air and heat surrounding the vital germ of the plant. We have already observed in another connection that too wet or too dry conditions are unfavorable. The soil must be moist but not wet. The temperature must be considerably above freezing and considerably below the highest degree at which vegetation ceases. It is very apparent therefore that the first and third mentioned objects of tillage are difficult to separate.

A good seed bed involves further the right texture of the soil for the easy penetration of plant rootlets. The cohesion of soil particles offers resistance alike to the development of roots and the movements of air and of water. The destruction of cohesion producing a fine granular condition of the soil is favorable to good tilth.

Soils in perfect tilth are neither so loose that they fall apart and

dry out, nor so close in texture that the grains appear to be cemented into solid masses.

Temperature of soils is also influenced by tillage. When the balmy spring air and warm showers penetrate the surface they warm it to a better degree for growing crops. Evaporation withdraws heat and makes the soil cold. Checking evaporation by an earth mulch on the surface prevents undue lowering of temperature in the production of vapor. Growing plants require air about their roots.

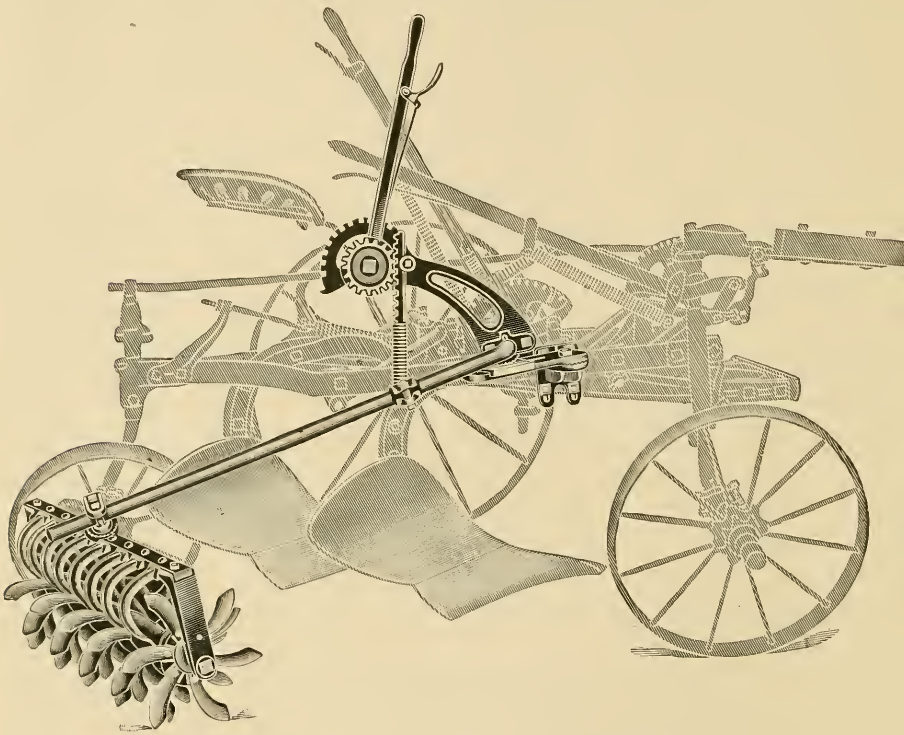


Fig. 19. SPADING HARROW ATTACHMENT.
(Courtesy E. M. Kramer Co., Paxton, Ill.)

Very few species thrive with roots under water. A mellow soil admitting the air without destroying the capillary movements of water is a favorable seed bed.

Tillage aims to form a suitable seed bed then, by producing the proper texture of the soil; and exerts a favorable influence on soil temperature, moisture and air.

Removing Organic Matter. There are two parts to this subject: I. Destroying undesirable plant life. II. Incorporating dead matter in the soil.

In breaking up there may be wild nature or perennial plants, of value in their place, that must be gotten rid of to allow the full occupation of the soil by the desired crop. The first process in tillage therefore is the destruction of all undesirable plant life. This is generally best accomplished by plowing, thus burying the vegetable matter so deep that the plants die. Another benefit comes from this operation, viz: getting the organic matter out of the way of surface tillage.

The destruction of weeds by uprooting and burying during the growth of the crop involves other tillage problems and methods.

The second part of the removal of organic matter, that of incorporating it with the soil, has an important bearing on fertility in three ways.

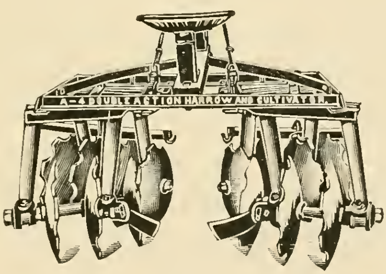


Fig. 20. DOUBLE ACTION CUTAWAY HARROW.
(Courtesy Cutaway Harrow Co., Higganum, Conn.)

First, it improves the texture of the soil by separating the soil grains, preventing a puddled condition. No doubt many soils can be greatly improved in texture by the addition of vegetable matter, stubble, green manure, etc.

Second, the addition of humus to the soil with its complement of plant food and its benefit to temperature.

Third, the organic acids, produced in the decomposition of vegetable matter into humus, have a solvent action on soil compounds. Mineral salts used as food by plants are thus dissolved by the decomposing organic matter.

Regulation of Moisture and Air. The effect of tillage in check-

ing evaporation and thus conserving the soil moisture has been explained in another connection. It has also been shown that rains and snows are more completely absorbed by lands where the surface has been broken and stirred. So far as the semi-arid lands of Montana are concerned the increase in the gathering and holding power is by far the most important item of moisture regulation.

A moist condition is also favorable to the preparation of plant food. Bacterial action takes place in a moist medium and the nitrification (preparation of nitric acid) due to certain species found in soils is most rapid under moist conditions, and ceases when the ground dries out.

The effect of regulation of moisture in warming the soil has already been noted .

Air is essential to root growth just as much as is moisture. The admission of air is best effected by stirring and pulverizing the soil. Air must be admitted in such a way as not to reduce the water too much. A too loose condition is undesirable. The best condition is that of thorough pulverization into very fine particles with a degree of compactness admitting of free capillary movement of water in the soil.

PLOWING.

Two distinct effects are secured in plowing.

1. Inversion of the furrow slice.
2. Pulverization of the earth moved.

Upon the mechanical principle of the "compound wedge" worked out by Thomas Jefferson more than a century ago, plows were perfected to cut, lift and invert the furrow, leaving the turf and top soil of each furrow buried flat in the bottom of the preceding one. Timothy Pickering worked out the same principle under the term of "spiral wind". The first object of plowing is therefore to invert the top soil and cover any organic matter that may be upon the surface.

In the process of lifting and twisting the furrow slice more or less pulverization takes place. The longer the mouldboard and the smaller the angle of the wedges the less will the cohesion of soil particles be interfered with in plowing, while the sharper and more abrupt the act of lifting and turning the greater is the pulverizing effect.

Plows are varied somewhat to suit different requirements. Breaking plows and plows for sod land are designed with especial reference to completely inverting and covering the vegetable matter on the surface with little reference to pulverization while for stubble and old land a smoothly inverted furrow slice is less important and a shorter plow with more pulverizing action is used.

The character of the soil has an influence on the action of plows. Tenacious clays are more elastic and inclined to turn without breaking while loose sandy soils break and pulverize very easily. As a rule the finer the soil particles the less pulverization results from plowing. There are other factors—e. g., the degree of moisture—that have an influence on the pulverizing effect of plowng. If the soil is too wet plowing puddles it and seriously injures its texture; if too dry it makes it lumpy and coarse. Just the right degree of moisture allows the plow to pulverize soil into a fine and desirable tilth.

DEPTH TO PLOW.

No hard and fast rule can be laid down for the depth of plowing. This is a question to be determined individually in each case with reference to season, crop and condition and character of the soil. In humid climates it is unwise to plow below the dark humus soil on the surface for turning up the light colored subsoil works injury to fertility.

Undoubtedly it is advantageous to secure as great a depth of tilled soil as circumstances will permit and the gradual deepening of soils by plowing is good husbandry.

Experience on semi-arid lands is too limited to warrant a fixed rule for depth of plowing. Success has been achieved with both shallow and deep plowing and failures have made very little distinction in this regard.

In Utah three years' experiments on semi-arid lands in several localities gave the highest average yields of crops where land was plowed five inches in depth.

Many Montana soils appear to be uniform to almost unlimited depth so far as tillage is concerned and there is no possibility of turning up a light colored under soil. In such cases under proper conditions and at the proper time the deeper the plowing the better.

Fall plowing may generally go deeper than spring plowing as

the soil has a chance to settle during the winter and the capillary action of water is established before the crop starts in the spring.

It is of great importance where seeding closely follows plowing to compact the under soil sufficiently to insure capillary connection with the unstirred subsoil.

KIND OF PLOWS.

For most purposes a medium right hand sod plow is useful, and special types with limited adaptability are unnecessary. Where much work is done and several plows are needed it will pay to purchase with regard to the particular use in view.

Single right hand plows 12 to 16 inch, are in most general use. Gang plows are labor savers enabling one man to keep several horses at work. Montana soils generally require from one half more to twice as much horse power as humid lands farther east. Six to eight horses are commonly used on a two plow gang in this state.

Reversible plows turning the furrows all one way, are more commonly found in the older agricultural states than in the semi-arid country.

Rod breaker plows, in which steel rods take the place of a solid mould board, have been been found useful in breaking prairie ground in some sections but are uncommon in Montana.

Disk plows and particularly disk gangs are gaining in popularity, although their use is somewhat limited. Their pulverizing action is greater than in the standard plows but they do not turn under sod as completely nor do they move all the soil. They are somewhat lighter in draft and work in harder soils than standard plows.

Sulky or riding plows probably enable the driver to accomplish more work than he would do walking. The draft has not been found materially greater although considering the greater amount of work accomplished more power is desirable. For gang plows, sulkies are in general use.

Subsoil plows are used in the bottom of the furrow to loosen and pulverize the subsoil without inverting or bringing it to the surface. Their effect has been beneficial to the crop in many instances. Much depends on the condition of the subsoil as regards moisture. If either too wet or too dry the subsoil is more likely to be injured than improved by plowing.

STEAM PLOWING.

There are many advantages in the use of the high power traction engines in tilling the large areas of semi-arid lands. By their use work can be done that is practically impossible with horse

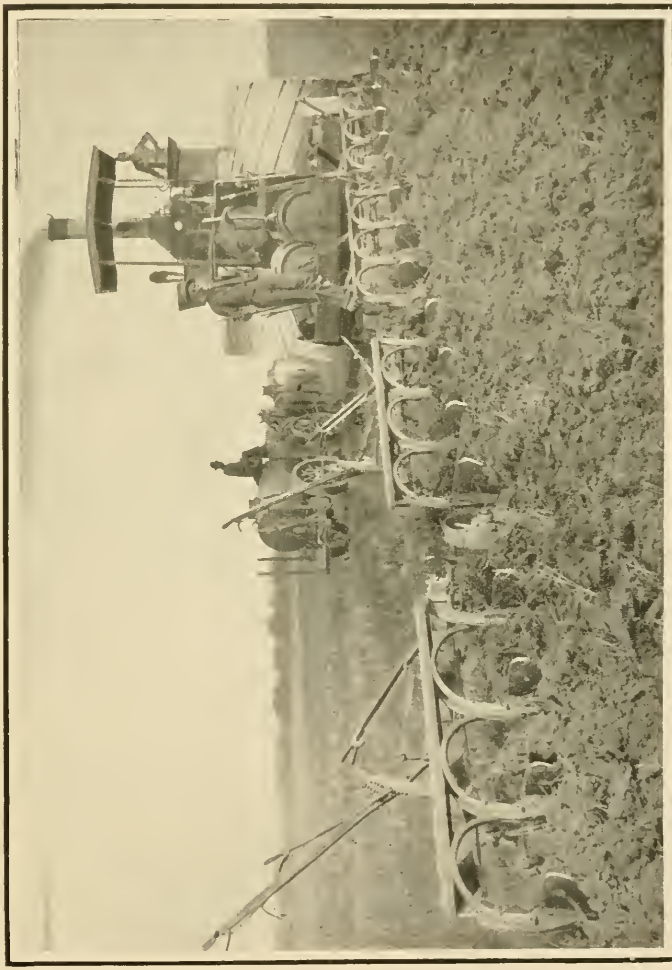


Fig. 21. STEAM PLOWING OUTFIT.
(Courtesy Best Mf'g. Co., San Leandro, Calif.)

power. Lands may be broken where horses cannot pull a plow and a depth of plowing impossible with horses can be secured.

Economy is, however, the great desideratum in the use of trac-

tion engines. During the rush season by working night shifts a traction engine may plow forty acres daily or twenty-five acres with one shift. This reduces the required number of laborers. Power is necessary at threshing time and may be utilized at other seasons in tillage and harvesting the crop with small additional investment.

Both steam and gasoline engines are used in plowing. The latter possesses the advantage of economy of fuel and water where these are scarce and expensive; but the former are regarded as more reliable and are at present in far more general use.

Particular emphasis is placed on the adaptability of high power motors on arid farms, where areas and distances are great. They enable the arid farmer to spread himself and carry on many times greater acreage than is possible under irrigation. This is a compensation for the advantages of the latter system.

WHEN TO PLOW.

Days required for plowing on a large dry land farm are many and long. There are times when other imperative operations of seeding, tillage and harvest preclude plowing. There is a frozen winter season when plowing is impossible and also a season when the ground is too dry to make plowing advisable. Plowing must therefore be done when other farm work and the physical condition of the soil will permit. There is some elasticity as to season and the farmer's judgment must be his guide. These seasons may be mentioned for plowing:

1. Fall.
2. Spring.
3. Summer.

For spring seeding **fall plowing** has many advantages and is generally recommended and preferred. It helps to conserve the moisture already in the soil. It enables the ground to take up and hold winter precipitation better. It exposes the soil to the disintegrating action of frost, bringing mineral plant food into solution. It allows the ground to settle into a seed bed of the right degree of compactness.

Spring plowing is also good practice, but is more adapted to later than early seeding. The strenuous work of harvest, threshing and marketing of the products of the farm place limitations upon the amount of plowing that it is possible to do in the fall. Spring in-

cludes many long days when the farmer can plow to good advantage. These may well be used for the purpose for the ground is usually in splendid physical condition. Spring plowed land must be carefully handled to secure the best results by:

1. Plowing to a shallower depth.
2. Forming an earth mulch with the harrow.
3. Packing the sub-surface to form a good seed bed.

Summer plowing may be done after the seeding is over before the harvest commences if the ground is in suitable condition. The rainy season in Montana commonly makes early to mid-summer a favorable time to plow for summer fallow and fall grains. It is a particularly good time for breaking new ground. In summer breaking care must be used to lay the furrows down evenly, then roll or pack them close to the subsoil, following immediately with the harrow to fill up the spaces and make a surface mulch. Sod ground can be plowed with safety when considerably wetter than old land.

HOW OFTEN TO PLOW.

Some variety of opinion and practice exists on this question. It is common practice to grow three crops with one plowing, using the harrow only to prepare the ground for the second and third crops. If a much larger crop can be secured by a little extra labor in plowing it is poor economy to withhold it. Where the system of summer tillage is practiced and fifty bushels of wheat to the acre is grown each alternate year it is not believed that one plowing will be too much for each crop, and for the alternate system with spring grains two plowings may be found profitable.

SUB-SURFACE PACKING.

One of the more recently described operations of tillage, belonging to the Campbell system and of which he was the originator, is sub-surface packing.

The object of this operation is to produce a firm and uniform condition in the under portion of the surface soil after plowing. The action of the packer is quite different from that of the roller, which compacts the surface soil only, in that it packs the deeper soil and leaves the surface loose. By thus compacting the sub-

surface its connection with the subsoil is established and the movement of capillary water is permitted in the under portion of the plowed soil. If this is not done the sub-surface will be too loose

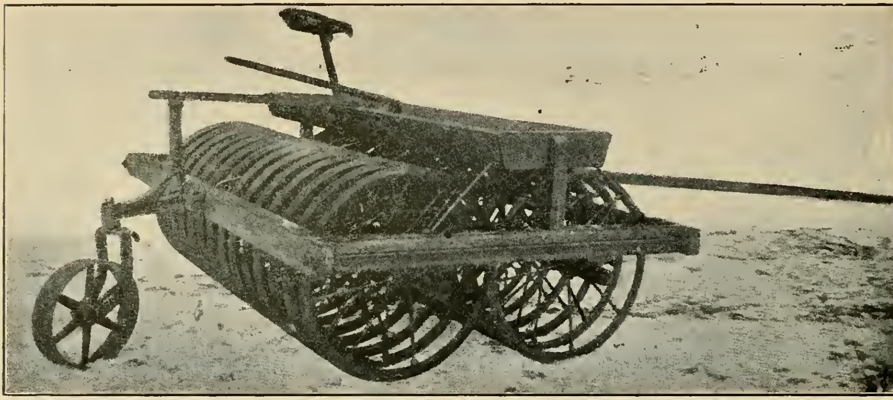


Fig.22.—SUB-SURFACE PACKER.
(Courtesy Better Fruit, Hood River, Ore.)

for capillary action, will dry out and although rich in plant food will be incapable of supporting satisfactory crop growth.

The packer produces a condition favorable to the rise of subsoil moisture into the under portion of the plowed surface by breaking up the clods, closing the large air spaces and bringing the soil

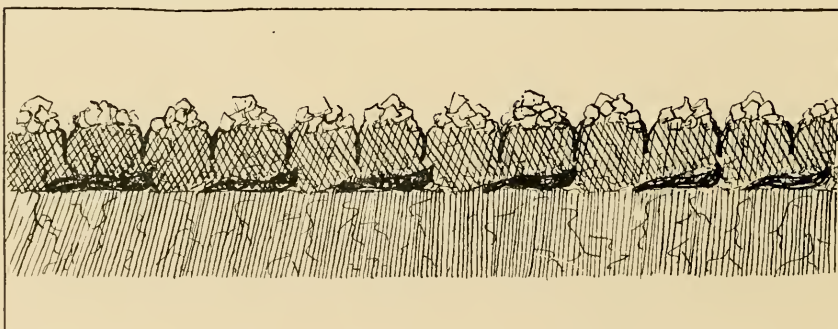


Fig. 23. TILTED FURROWS, PACKED.

grains nearer together. The rootlets of young plants do not develop in dry soil but follow the moist portions. If the subsurface is loose and dry with no capillary connection with the subsoil, vegtation cannot flourish because of restricted root pasturage.

By deep seeding so that the subsoil moisture may aid in the germination and growth of plants some assurance of a crop is obtained; but until the surface connection has been made mechan

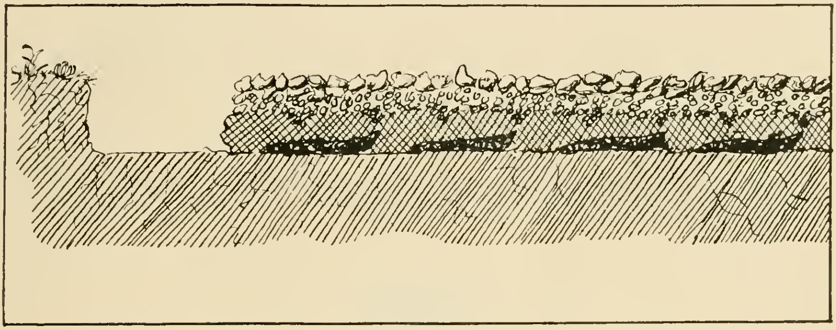


Fig. 24. TILTED FURROWS, PACKED AND HARROWED.

ically, the most fertile portion of the soil cannot contribute to its full development and yield.

The packer produces a favorable condition for germination and growth nearer the surface, renders deep seeding unnecessary, and opens up the fertile surface soil to vegetation. It is of especial value on spring plowing.

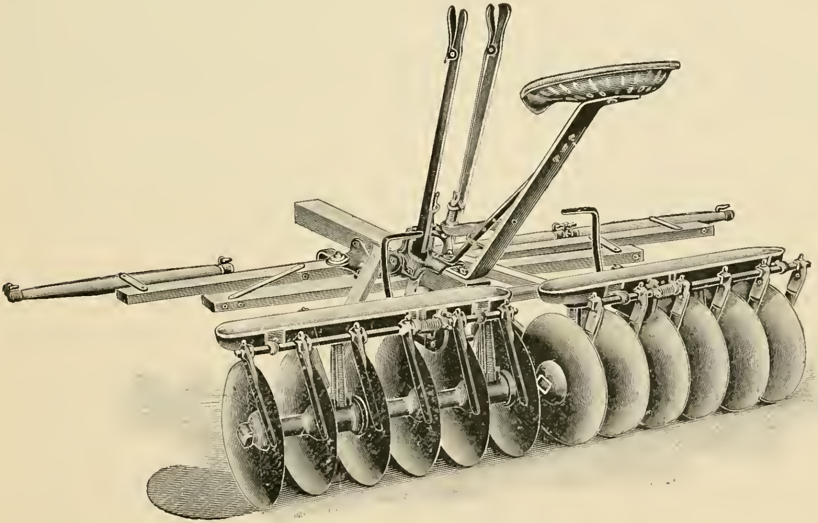


Fig. 25. DISK HARROW.
(Courtesy Superior Drill Co., Springfield, Ohio.)

HARROWING.

The object of harrowing is the pulverization or fining of the soil and the development of perfect tilth. Its work commonly supplements that of the plow although in many instances—more often than good husbandry dictates—land is harrowed without plowing. There are four types of harrows which we consider, viz:

1. The disk.
2. The spring tooth.
3. The shares or acme.
4. The spike tooth or smoothing.

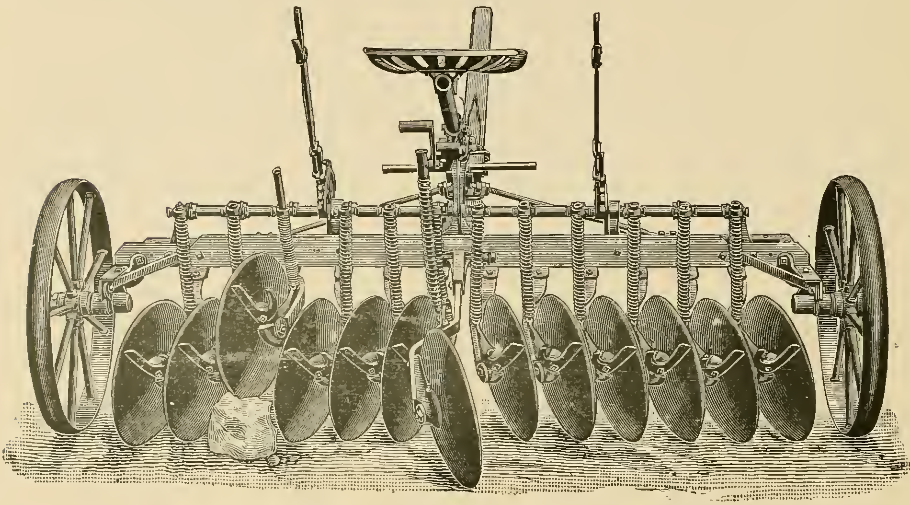


Fig. 26. DISK HARROW WITH INDEPENDENT DISKS.
(Courtesy Superior Drill Co., Springfield, Ohio.)

DISK HARROWS.

No tillage implement performs more important work than the disk harrow. There is no harrow that so thoroughly pulverizes fall plowed land in the spring and its capacity for digging up old land has led, in many instances, to its use without plowing. When set to work deep the draft is heavy, but it does a large amount of work. In hard ground free from tight or large boulders it finds its best use.

To secure the proper surface the disk should always lap half (double disking), otherwise a furrow is left in the middle of the harrow track and a ridge on its outer edge. The furrow allows the

evaporation of much water and leaves a scanty covering of fine earth. A special type of disk harrow known as the **double action** is represented in figure 20 which performs the right and left disking in one operation.

The correct method of disking is to work lengthwise of the furrow leading with the right lap. On right hand plowing this tends to press down the furrow and supplement the plowing, instead of turning back the sod which would be the tendency if the left disks lead.

If plowing is well done there is little practical difference

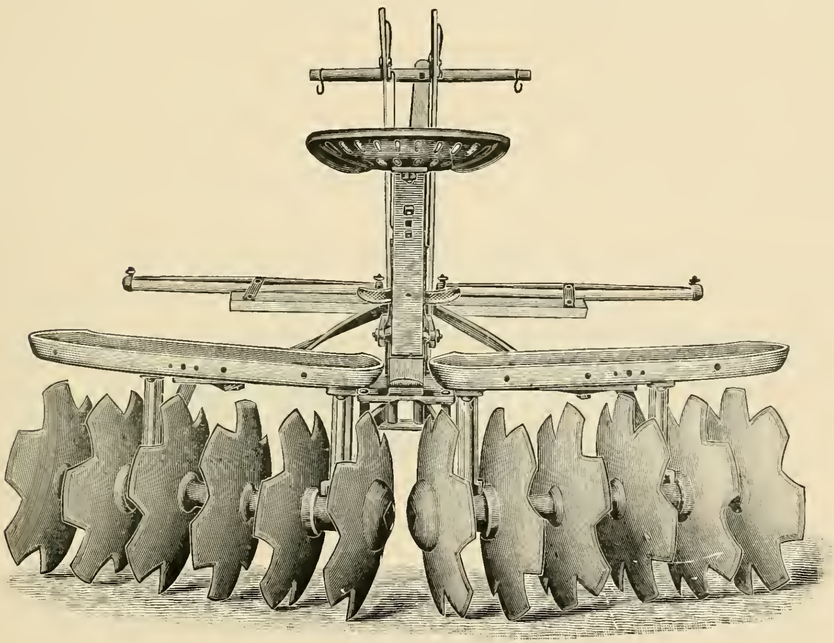


Fig. 27. CUTAWAY HARROW.
(Courtesy Superior Drill Co., Springfield, Ohio.)

whether the harrow lead is right or left. Cross disking is practiced to good effect but this is best done after disking lengthwise and often with an interval of a week or two between the operations. Diagonal disking also works well in a season's tillage. Among the useful purposes of disking are:

1. Pulverizing the surface before plowing.
2. Disking grain stubble right after harvest to conserve water.

3. Pulverizing fall plowed land in the spring.
4. Tillage of orchards to kill weeds and conserve water.
5. Pulverizing any ground to make a seed bed.
6. Summer tillage to maintain an earth mulch.
7. Following the plow to check evaporation.

Modifications of the disk harrow are the cutaway where notches are cut out of the edges of the disc, breaking the cutting edges. Cutaway harrows are said to do their work with lighter draft than solid disks.

Spading harrows carry the cutaway effect a step further and form a series of spades revolving on an axis.

SIZE OF DISKS.

The first disk harrows I ever saw had 12 inch disks. The di-

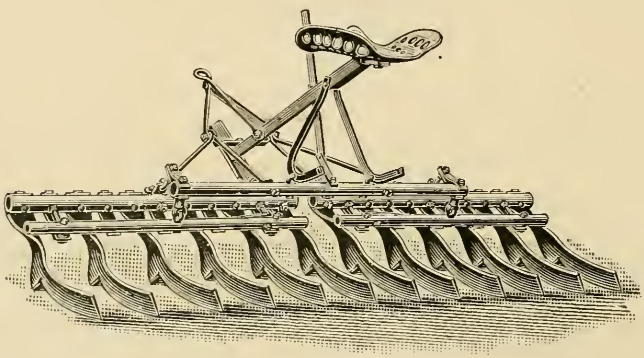


Fig. 28. ACME HARROW.
(Duane H. Nash, Millington, N. J.)

ameter has been increased to 14, 16 and even 20 inches. Expert opinion is that the larger disks, although lighter in draft do not pulverize as thoroughly as the smaller ones which revolve more rapidly. A 16 inch disk is more likely to give satisfactory results than one 20 inches in diameter.

The angle at which the disks are set with the line of draft has an important influence on the pulverizing action of the harrow. The wider the angle the greater its pulverizing effect. A sharp angle increases draft and may turn up sods. The operator must exercise judgment and set the harrow to suit the conditions of the work in hand.

The spring tooth harrow is extensively used and is a good implement under certain conditions. On stumpy, stony or rough land it finds its special fitness. Its weight forces the teeth into the ground and their flexibility prevents breakage. On smooth land with fine soil the disk is much more effective.

Shares or acme harrows are constructed on the principle of gangs of small plows with pulverizing but not inverting action. They are particularly adapted to mellow ground and are useful in working down old ground freshly plowed. Their draft is less than that of disk harrows, hence a team can take a wider sweep and cover much more ground in a day. They leave the surface smooth and do not require lapping. In many sections the acme harrow is used after the disk to smooth the surface. Working the acme across or diagonally across the track of the disk harrow gives the best results. For working down old ground plowed in the spring the acme is all right. It will also fit mellow ground much more cheaply than will the disk harrow.

The smoothing harrow is too well known to require much comment. The best style is a steel frame in sections with levers for adjusting the angle of the teeth. Square or diamond shaped teeth are preferred to round. It is used as a finishing harrow to give a finely pulverized and smooth surface. Among the applications of the smoothing harrow are:

1. Smoothing and finishing the seed bed.
2. Killing weeds.
3. Making earth mulch to check evaporation.
4. Breaking the soil crust about young growing grain.
5. Working down newly plowed ground to conserve moisture.

One man and four horses can smooth harrow thirty to forty acres of land in a day. Most of the fall grains and some of the spring sown crops are greatly benefited by harrowing as the ground dries out after spring rains. Injury by pulling out an occasional grain plant is insignificant when compared with the benefit in breaking up the surface crust, conserving moisture and destroying weeds. The teeth are set slanting well back for this operation.

The weeder is much used in the eastern states for lightly stirring the soil and killing small weeds in growing crops. It is constructed with three ranks of curved flexible teeth which carry a frame fifteen to twenty inches from the ground. In mellow soil it

is very effective; but where the ground is hard, a heavier implement is needed. Potatoes, corn and other crops may be tilled with the weeder after they are several inches high. I have used it in in corn two feet high without injury to the crop. It is a great labor saver, doing its work very rapidly. To give satisfactory results it must be used before the ground gets hard or the weeds get well started. By using the weeder once in every five to eight days, occasionally stirring the ground deeper with a cultivator, intertilled crops may be kept free from weeds and the ground in fine condition with small expense.

The roller is used to smooth and firm the surface and crush

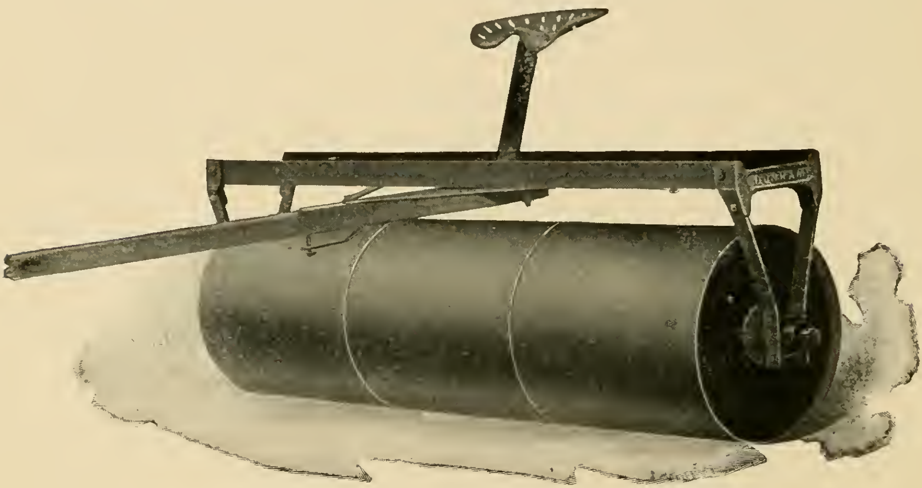


Fig. 29. LAND ROLLER.
(Courtesy of J. W. Dunham, Berea, O.)

clods. It has very little action on the soil a few inches below the surface. Rolling freshly turned sod is often advisable, to press the furrow slice down in the bottom of the furrow, closing the spaces and assisting disintegration. It is generally advisable to follow the roller with the harrow to prevent blowing and check evaporation.

The planker, made by bolting four 3 inch planks to two cross pieces in such a way that they slide over the land surface, presenting a sharp edge of each plank to the ground, is useful in smoothing the surface and crushing the clods. Its action is somewhat like

the roller but instead of pressing down vertically it slides across the field shaving off the high places and filling the depressions. Its

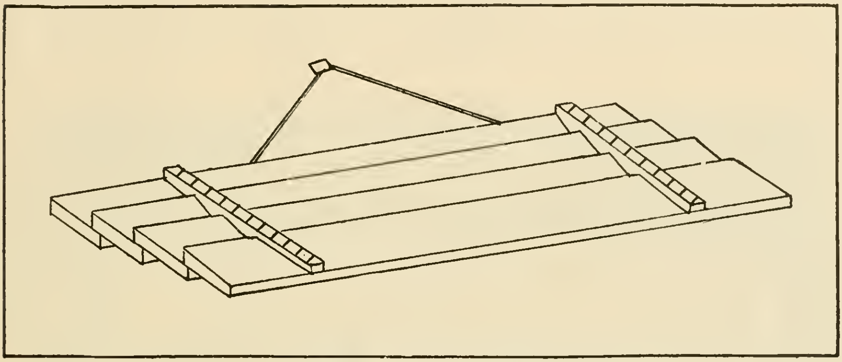


Fig. 30. PLANKER.

action in pulverizing and clod crushing is superior to that of the roller but its firming packing action is not so great.

SEEDING.

Having prepared a good seed bed by deep plowing, thoroughly

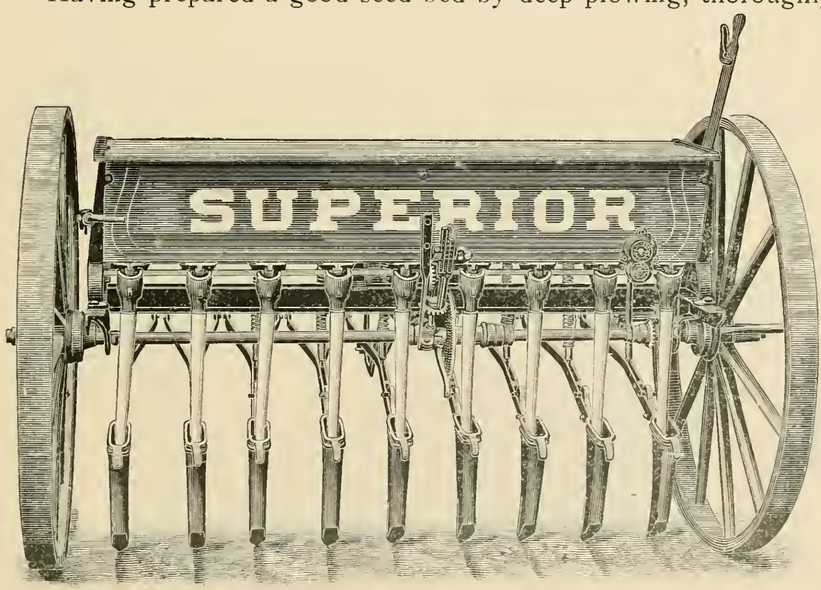


Fig. 31. HOE DRILL.
(Courtesy Superior Drill Co., Springfield, Ohio.)

packing the subsurface, and pulverizing the surface soil, we are ready for the seed. Broadcast seeding, discarded on humid farms

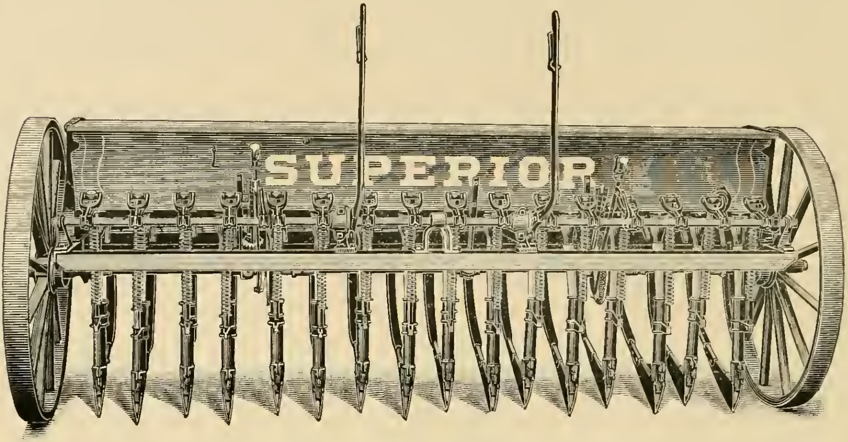


Fig. 32. SHOE DRILL.
(Courtesy Superior Drill Co., Springfield, Ohio.)

as unsatisfactory, is suicidal on arid lands. Several types of drills which are in general use are illustrated, each having points of ad-

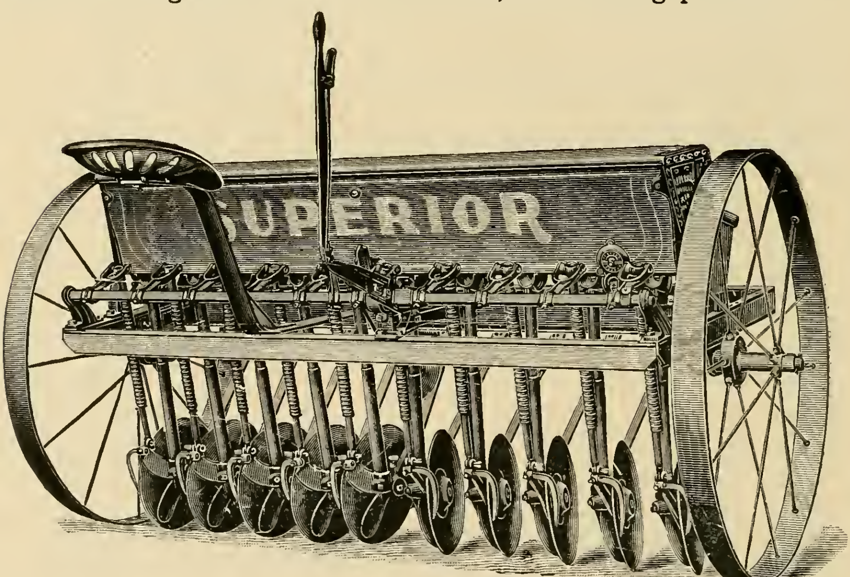


Fig. 33. SINGLE DISK DRILL.
(Courtesy Superior Drill Co., Springfield, Ohio.)

vantage which commend it for certain localities and conditions

Campbell in his manual, gives preference to the closed heel shoe drill as making the best germinating conditions about the seed; but in his comparison with the press drill he gives the latter the bad handicap of an unpacked subsurface which destroys the value of the comparison.

The Montana Experiment Station has invariably secured the best results in Montana soils with the disk press drill which puts the seed in very deeply and presses the earth covering it. Here again the work of preparation has not included the use of the sub-surface

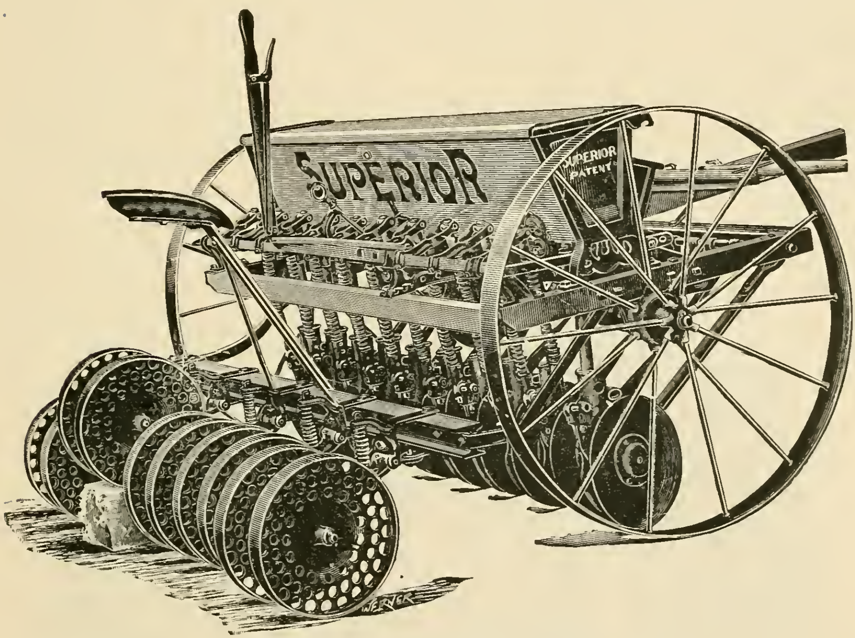


Fig. 34. **DISK PRESS DRILL.**
(Courtesy Superior Drill Co., Springfield, Ohio.)

packer, which might render very deep seeding unnecessary. The choice of a drill depends therefore on the condition of the ground before seeding. If the subsurface is well packed and the surface well pulverized and mellow, seeding may be shallower than where the subsurface is too loose to hold moisture for germinating the seed.

A press drill which firms the moist earth about the seed, creates the best conditions, will give quicker germination, a better stand,

and require less seed than a drill which leaves the seed in loose and dry earth.

Germination may be improved with a drill that does not press the earth about the seed, by firming the surface after the seeder with a roller and then harrowing to check evaporation and prevent blowing.

Depth of seeding depends on the condition and character of the soil, but must generally be deeper in an arid than in a humid climate. Land that is fall plowed and well settled need not be seeded so deeply as loose spring plowed ground. The subsurface packer makes it possible to seed shallower than where it is not used. The farmer must develop and use good judgment in regard to depth of seeding. The best depth is the nearest point to the surface at which perfect germinating conditions are found,—i. e., where there is the right degree of moisture and warmth. The warm fertile surface soil, if sufficiently moist, affords the best feeding ground for plant roots, as well as the best seed bed.

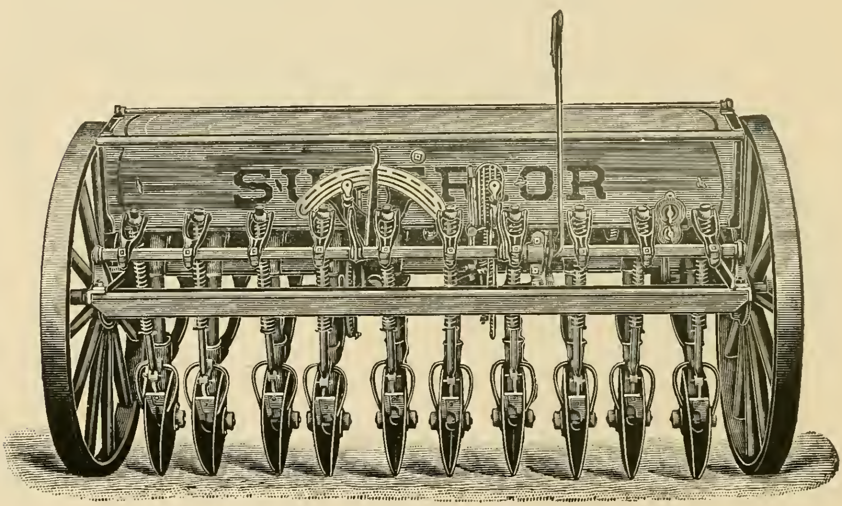


Fig. 35. DOUBLE DISK DRILL.
(Courtesy Superior Drill Co., Springfield, Ohio.)

Amount of Seed. Over seeding is wasteful not only in the cost of seed, but of the limited stores of moisture in the soil afterwards. Practical experience on semi-arid farms has shown that the largest yields of crop follow light seeding. The common practice of putting

in 1½ to 2 bushels of seed per acre is wrong on dry land.

The average* of all experiments of the Montana Experiment Station in Teton, Rosebud and Chouteau counties in 1906 gave the following returns from varying amounts of seed.

Crop.	Amount of seed per acre.	Yield of grain.
Spring wheat	3 pecks	14.44
	5 pecks	11.94
	8 pecks	11.30
Oats	3 pecks	30.75
	5 pecks	30.61
	8 pecks	24.44
Barley	3 pecks	23.08
	5 pecks	21.77

Every trial gave better yields with three pecks of seed per acre than with a larger amount and it is not certain that even less than three pecks might not have produced a full crop.

**Utah experience shows the best yields of grain where from two to four pecks of seed per acre were used.

Campbell states*** "For well fitted summer tilled fields the following quantity of good seeds is most desirable when the seeding is done sufficiently early; winter wheat, 18 to 20 pounds; spring wheat, 20 to 25 pounds; barley, 35 to 40 pounds per acre.

If the farmer has properly prepared his ground, carefully selected his seed and puts it in under good germinating conditions from two to three pecks of seed per acre is enough for semi-arid land.

INTERTILLAGE.

Intertilled crops, (i. e., crops that are cultivated between rows during the season of growth) are well adapted to the dry farm system. Where latitude and elevation are not so high as to preclude their maturing, corn, beets, squashes, tomatoes, beans, potatoes and in short nearly all intertilled crops can be successfully grown under a system of moisture conservation. Such crops have the additional advantage of allowing the maintenance of a soil mulch during the period of growth, thus economizing the store of water in a high degree.

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*Bul. 63, page 30.

**Annual No. 10, 1907, page 31.

***Soil Culture Manual, p 271.

Corn, the greatest single crop of America which is intertilled nearly throughout the season, produces a ton of dry matter with the least expenditure of water of any of our important crops. It is possible that a system of intertillage for cereal grains will be devised and put into practice on our arid farms before long.

The same principle applies to intertillage as to summer fallowing. Till often! Never let a crust form on the surface! Never allow the weeds to start! The dry farmer can't afford water to grow weeds. Weeds are often a blessing in disguise. They compel tillage, which would otherwise be neglected. If the farmer tills his ground often enough to keep it free from weeds there will be only a relatively small loss of its water by evaporation.

There are several kinds of cultivators in use for intertillage work, from the small garden cultivator, which needs to go twice to each row to thoroughly stir the ground, to those which work from two to four rows at a time. There are those with spike teeth for shallow work, and those with broad long shovels for deep tillage.

Weeders are used for intertillage and a disk harrow has been adapted to the same use. Besides there are cultivators with horizontal blades for surface cultivation. Level tillage is best. Deep tillage may be practiced while the crop is starting, to improve the texture of the soil, but after midseason this not only causes destructive root pruning, but also tends to dry out the surface soil, and restrict root pasturage where plant food is most abundant. Shallow tillage frequently performed is best in the majority of cases. Intertillage has a favorable effect on the temperature of the soil and on the solution of plant food, as well as on tilth and conservation of moisture.

Harvesting is a more extensive operation on the dry land farm than with irrigation. The harvest in the former case demands not only a more extensive equipment; but requires some variation in kind as well. Two types of harvester are worth considering that are not in general use in Montana and not likely to find favor on small sized irrigated farms, viz. the header and the combined harvester.

The Header takes the grain and only a small portion of the straw, leaving the greater part of the straw standing in the field to assist in conserving the moisture and improving the texture of the

soil. With the short straw varieties of grain advocated for dry land farming the header seems to be a desirable implement. It is extensively used under similar conditions in Utah and other semi-arid states.. Its advantages over the binder lie in its greater capacity and the elimination of the work of shocking grain in the field.

The Combined Harvester cuts, threshes, cleans and sacks the grain at one operation and is therefore a great labor saver. It takes a wide sweep (25 ft. swath) and is generally hauled by traction engine, although in some sections horses are used. With the large areas farmed and the use of steam power in other operations, the economy of rapid work, few handlings of the product and a minimum of hand labor required, the advantage of the combined harvester is readily understood and its advent on the arid farms of Montana is confidently expected.

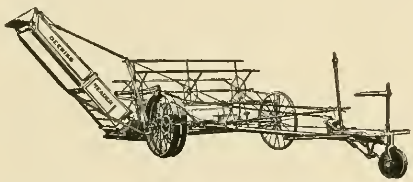

Fig. 36. GRAIN HEADER.
(Courtesy International Harvester Co., Chicago, Ill.)

WIDE TIRE VEHICLES.

Most of the hauling in Montana is done with vehicles having about a 2 inch gear. While this is permissible over hard surfaces, there is no doubt that earth roads are kept in better shape where wide tire vehicles are used. Certainly the narrow tire is bad to use on tillage land. Not only is it heavier in draft but it is injurious to the tilth of the ground over which it passes.

Buy wider tired wagons, therefore, for farm work.

Fig. 37. COMBINED HARVESTER.

32 foot swath, 54 inch cylinder, 110 H. P. engine; capacity 1000 sacks grain daily. (Courtesy Best Mf'g. Co., San Leandro, California.)

CHAPTER VI.

THE CAMPBELL SYSTEM; WHAT IS IT?

By H. W. CAMPBELL.

Fig. 38. H. W. CAMPBELL, LINCOLN, NEB.

The Campbell System of Soil Culture stands today for very much more than it did years ago.

In the period from 1883 to 1898 our efforts were mainly along the line of preventing the ill effects of drouthy seasons upon the general crop yield, and in this line of research much was accomplished. In 1898 we began a broader and more elaborate study of Scientific Soil Culture.

We became fully convinced by the results of our work in 1896 and 1897 that the average yield of all fields, whether in the more humid sections with their greater rainfall, the more arid or semi-

arid sections having a lesser rainfall combined with grave uncertainty as to timeliness and quantity, or under irrigation—in short by the common methods of soil treatment practiced under all conditions and in all sections of the country—that the average yield of grain was not half what it might be or should be if the methods of tillage were materially changed.

Prompted by these conclusions reached after fifteen years of experience and observation, we started out to prove by practical demonstration that the average yield of all farm crops could be easily doubled by simply changing the method of tilling the soil and without resorting to commercial fertilizers. That these ten years of research have not been in vain is evidenced by the results achieved at numerous places all over the semi-arid belt.

RESULTS IN ALL REGIONS.

In seasons of drouth when others by the more common methods of farming have grown from nothing to 8 or 10 bushels of wheat there has been grown under our method of tillage from 30 to 40 bushels per acre.

In the more favorable seasons, when others have produced by the common methods from 15 to 25 bushels per acre, there has been grown under methods of tillage we have outlined from 40 to 60 and over bushels of wheat per acre.

It has also been proved by experience that by the application of the same fundamental principles the yield of all crops can be proportionally increased.

The fundamental principles of the Campbell System of Scientific Soil Culture apply to crop growing in all sections, and we are fully justified in claiming that the average yield can be materially increased; but when we turn to the semi-arid section these principles become vital.

LOOKING TO THE SOIL.

Our present system of tillage is not a combination of rigid rules outlining certain mechanical work that must be done under any and all conditions, the result of continued experiments in deep and shallow plowing, deep and shallow cultivation, etc. It looks rather to the condition of the soil as maintained from year to year.

In 1896 we conducted experiments in eleven different places along the lines of the Burlington railroad, the Northern Pacific and the Soo Line, receiving financial aid from all of these companies, the fields being located in North Dakota, Nebraska, Kansas and Colorado. In 1897 the Fremont and Elkhorn railway came in for a share of the work and more stations were added on the other roads, making a total of over thirty.

Through a chain of circumstances connected with these farms we reached the conclusion that the crop growth and grain yield was governed largely by the physical condition of the soil, and careful experiments the past ten years have shown this to have been an important step by leading up to investigations along this special line.

MOISTURE CONSERVATION.

While the conservation of the moisture is an important factor it is by no means all. It is only one of many vital things to be carefully considered if we are to reach the high limit of yield in all fields that now seems possible.

We do not wish to convey the idea that our system is so elaborate and full of details that the average farmer cannot grasp it in its entirety, for it is not. Yet there are so many details, every one of which must be fully understood, that it is entirely out of the question to cover the field as we now understand it in so short space. We can only deal with the main or fundamental principles.

SOIL CONDITION.

The physical or mechanical condition of the soil is the all important factor, as it has more to do with the quantity and quality of the crop yield than any other one thing. If the seed and root bed is not properly prepared all the after cultivation cannot bring the highest yield. No matter how much moisture you have conserved in the soil below or how completely you may keep the weeds out you cannot reach the high limit of yield without close and careful attention to the preparation of the soil.

AIR AND WATER.

Air is just as necessary an element in the soil as the water, but both must be there in proper quantities. If there is too much air

and too little moisture nitrification ceases. If there is too much moisture and too little air the effect is the same. From 10 years' experience and observation we have concluded that a certain chemical action must be practically continuous in the soil during the growing season if we are to grow the largest crops. This chemical action is unquestionably dependent upon just a certain ideal or perfect condition of the soil—a physical condition that will carry in the soil just the ideal quantity of both air and water—and then as soon as the soil becomes sufficiently warm nature's work begins.

THE SOIL MULCH.

The soil mulch is for three purposes—to more readily admit the rain when it comes, to admit of a free circulation of the air into the soil and to prevent the loss of moisture by evaporation.

Sometimes the cultivation is not deep enough or sufficiently frequent and a crust forms at the top of the firm soil underneath the mulch. This crust shuts out the air to a degree and it matters little then how perfect may be the supply of moisture at the roots, for the growth will certainly be checked.

NITRIFICATION.

That nitrification is a necessity in the soil during the crop growing season is unquestionably true. If the process of nitrification is going on sufficiently to meet the requirements of the crop this is always evidenced by the dark green and healthy appearance of the plant.

One illustration with reference to this may be quite clearly seen by noting the condition of a fence post. The portion above ground where the air is plentiful and moisture lax remains in perfect condition, and deep down in the soil where the moisture is ample and air scarce the post is always well preserved; but just at or near the top of the ground the post is decomposed, indicating that just the proper quantity of both air and moisture was present together with the heat to assure decomposition and nitrification.

BIG CROPS.

It is unquestionably true that the farmer has it within his power to practically control the yielding powers of the soil, barring

hail or insect pests, if he but understands the true fundamental principles of soil culture and plant growth. Judging from experience we believe we can grow larger crops of grains and vegetables under a 15-inch annual rainfall, on the average high level prairie, than is now grown by the average man who farms by irrigation. We do not believe we have reached the limit, but are hopeful that after further careful experimenting we will be able to produce a yield that cannot be surpassed by any farmer in the more humid sections of Iowa or Illinois, and this in the semi-arid belt. In short it is not a question of growing just a living crop so that the semi-arid belt may be inhabited by a class of farmers that barely exist but a question of growing larger crops every year than any of the more humid states now average. This is what the system stands for.

—Courtesy of Campbell's Scientific Farmer.

CHAPTER VII.

CAMPBELL'S CONTRIBUTION TO TILLAGE METHODS.

By DR. W. X. SUDDUTH.

Conservation of moisture through improved methods of tillage is the crowning triumph of the age.

There never was a time in the history of the world when the need of such labor was so great. The world's population is increasing so rapidly that the hitherto waste places of the earth are being sought for homes for the people. Wise statisticians studying the situation are predicting a bread famine in the very near future, unless something is done to increase the area of our tillable domain.

Western advancing civilization has long ago passed the line which marked the border of safety in cropping, and has boldly taken up its habitation in the midst of the great American desert; and still the movement is steadily landward and the cry of the starving operative in our crowded cities is, "Where may we find the manless land for the landless man."

Where may he find a home, where he may dwell in peace under his own vine and fig tree, away from the poverty, misery and degradation of our crowded and ever crowding cities? Is there any safe place where we may direct him where he may be assured of a living for himself and family? Long ago the conservative voice of the people said, under existing conditions and present methods of cultivation there is no such land, and still the movement was and has been landward.

Bleeding Kansas and starving South Dakota long ago told the world in a voice of thunder that the semi-arid regions were not a safe habitation and the prevailing opinion of the day is that it is nothing short of criminal to encourage settlement west of the 100th meridian. The privation and suffering of the early pioneers of the plains is a heart rending tale.

But still the movement is westward and the tide of immigration never was stronger than it is today. The people are coming, not in prairie schooners, as of old, but every train is unloading them

in large numbers at our very doors whether we will or no. The burning question is, what are we going to do with them?

Is this a safe land and can a home be made in the land of the sage brush and the coyote? Our answer is, Yes. Under modern methods of tillage even a land of from seven to ten inches of precipitation may be made inhabitable and support a dense population.

Central Montana has the most equable climate in the United States. What we owe the new comer is to educate him in modern methods of tillage, so that he may make good. The oceans and inland seas of the world are slowly but surely drying up. The area of humidity is steadily lessening,—contrary to opinions held by many. Scientific research bears me out in this statement.

Larger and larger areas of land possessed of lesser and still lessening precipitation are constantly being brought under cultivation. How to utilize this vast semi-arid area is the crying want of our day and generation.

Mr. Campbell comes as a prophet indeed, a bearer of good tidings, for by his methods the desert may verily be made to blossom as the rose, and the land that now produces only sage brush and cactus be made to flow with milk and honey and produce bread for the nations of the earth.

Mr. Campbell is no theorist but a simple man of the people, who has made good in every relation of life where he has been placed. He settled in Brown County, South Dakota, near what is now the town of Aberdeen in 1879,—this was in the trying days of that much tried state, and while others fainted and fell by the wayside, not by the thousands but by the tens of thousands, Mr. Campbell remained on his farm; too poor, as he himself has said, to get away. Necessity in his case, as in many another, was the mother of invention.

By careful study and experimentation he evolved a system of farming that has been the salvation of his own state and will be of benefit to all the states of the semi-arid belt wherever it is adopted. It is no discredit to Mr. Campbell that the principles that underlie his methods are not new, for the general practice of the summer fallow and intertillage of crops has held sway on the steppes of Russia and on the shores of the Baltic Sea for the last century.

For the long-suffering and greatly needy South Dakota farmers

of the early 80's they were new and as truly a new discovery as if they had never been discovered. Not only this, his method of application of the principle was original and adapated in a thoroughly scientific manner to the conditions and soil of his own locality.

While it is true that Utah and Oregon have been following the general practice of tilling the summer fallow in order to keep down the weeds for the past quarter of a century, yet to Mr. Campbell belongs the credit of tilling the soil in order to conserve the moisture and thus make possible the raising of crops in countries where the rainfall is insufficient for successful cropping otherwise. The vital difference between Mr. Campbell's method and the practice in vogue in Oregon and other countries that have adopted the summer

Fig. 39. DISK HARROW.
(Courtesy Superior Drill Co., Springfield, Ohio.)

fallow, is that they were forced to till their summer fallow in order to keep down the weeds and incidentally they developed a system of tillage that in a way tends to conserve the moisture; while Mr. Campbell, through careful study and observation, born of his need, evolved a system of moisture conservation, through improved methods of tillage, that was specially adapted to the parched land in S. Dakota, and as a result of his thorough methods of tillage he kept down the weeds, not, however, as a prime consideration but as a secondary consideration.

Mr. Campbell's propaganda first, last and all the time has been moisture conservation, the laying up of a bank account of water in the soil as an insurance against, not a rainy day, but to meet the pressing demand of the hot south winds of his locality. So that the growing crop should have ample moisture to draw upon in its time of greatest need, e. a., filling time. So has he perfected his system that where his methods are intelligently followed he affirms that there need never be a crop failure, even where the annual precipitation is as low as seven inches. His demonstration farm at Holdridge, Nebraska, was established in 1903. The first crop was hailed out but he made good in the great drouth year 1904 that followed, with yields of 41 bushels of wheat; while 90 per cent of the neighboring crops were complete failures. The Pomeroy farm, in western Kansas, was established in 1900. In 1904 his yield was 40½ bushels of wheat while the grain on adjoining farms was a total failure. Not since 1904 have we had a real dry year, but just as surely as we do have a recurrence of such a year will there be universal failure unless intelligent methods of storing moisture are put in practice.

As I have so often remarked it is simply inviting failure to put seed into the soil that does not at the time of planting contain sufficient moisture to make a fair crop, even should no more rain fall during the entire season. No need of guess work; moisture content of soils can be made by analysis. Mr. Campbell is indeed a prophet and a bearer of good tidings, a man among men, modest even to a fault; unassuming and diffident but a man nevertheless with the courage of his own convictions, and a man who has a message for the people and who is eager to propound his methods and elucidate his practices.

CHAPTER VIII.

DRY LAND CROPS AND CROP ROTATION.

By ALFRED ATKINSON.

Since crops vary in the ability to produce satisfactory returns under conditions of scant moisture supply; and again since certain systems of crop rotation seem especially adapted to the dry farm, a discussion of these two phases of the dry farm subject is presented herewith.

Fig. 40. STEAM PLOWING OUTFIT.
(Courtesy Geiser Mfg, Co., Waynesboro, Pa.)

DRY LAND CROPS.

In order that a crop may be satisfactory on the dry farm it must possess the following characters: strong early growth, early maturity, hardiness and a strong and comparatively deep rooting system.

Strong early growth is important in order that the crop may make the fullest use of the moisture that falls during April, May and June. During this period the soil is frequently cold, and weak growing plants come along slowly. The crop that will bring the highest returns must be able to make rapid growth during these months, in order that it will be well on towards maturity when the dry weather sets in the latter part of June and during July. If the crop is fully developed at this time the moisture in the soil will be sufficient to mature a large yield of plump grain, while if the moisture in the soil has to be expended in growing the stems after the rains cease, a small yield of only partly filled grains may be looked for. It is because of the root and stem development during the previous fall which makes for early maturity, that fall sown crops usually do better than spring seeded ones on the dry farm.

Throughout the dry farming areas the rainfall comes at varying intervals and in widely varying amounts. Some seasons, average showers fall periodically and so bring the crops along under most favorable conditions, while in other years the moisture comes in very heavy rainfalls with very hot dry spells between. Therefore the dry land crop that will be the most satisfactory will be the hardy one which is able to withstand both conditions of very heavy rainfall and of rather severe drouth.

Deep rooting is also a very necessary character in this class of crops. During May, 1908, rain fell in unusually heavy showers throughout the central and eastern part of Montana. As a result many of the dry land crops formed very shallow rooting systems because of the abundance of moisture present early. Later when the dry hot days began these crops suffered severely because of the very limited feeding area resulting from their small root system Had the habits of deep rooting been firmly fixed in these plants, feeders would have been sent out through the soil during the early spring, and plant food and moisture would have been carried to the plant in greater amounts during the period of drouth.

A class of crops that will find a place on the dry farm will be inter-tilled crops. These are planted in rows sufficiently far apart to permit of cultivation during the growing season. Crops like corn, sorghum, etc., while making rapid growth and presenting a large leaf surface for the evaporation of moisture, may be raised with a limited supply of water, since the intertillage that is possible be-

tween the rows prevents unnecessary evaporation of moisture from the soil.

Turning to a discussion of the dry land crops, we present in the following paragraphs the names of those crops that have shown themselves best adapted to meet the growth conditions on the farms above the irrigation ditch. As the years advance other crops will no doubt come to be included in this list, while some that may have a place at present will no doubt be set aside as comparatively unprofitable.

The following list of crops, with a brief discussion as to the management of each, is presented because of the satisfactory showing made by these crops on the experimental dry farms throughout Montana during the past three years.

FALL OR WINTER WHEAT.

Of all the grain crops so far grown on the experimental dry farms in Montana the Turkish red or Russian red variety of winter wheat has given decidedly the best returns. At the experiment farm in Rosebud county this crop yielded nearly 59 bushels per acre during 1907. The crop was imported originally from the drier parts of Europe and so is especially fitted for growth under dry conditions. It is a very high grade milling variety, almost equal to No. 1 hard spring.

Other varieties, such as the fall club, lofthouse and gold coin have given good returns. These have not yielded so high as the Turkish red variety and are not such high grade milling varieties.

The experience of the past three years as well as the observations for a longer period, indicates that fall wheat on the dry farm should be seeded early and with a comparatively small amount of seed. Planting the crop by the middle or 25th of August at the rate of three pecks of seed per acre, has given better returns than later planting or heavier seeding. When seeded too heavily much of the moisture is wasted, producing the large growth of stems with the result that little is present to develop large plump grains at ripening time. Again, when the crop is seeded too late some of the growth that might as well be gained during the fall is lost and so the crop is seriously delayed the following spring.

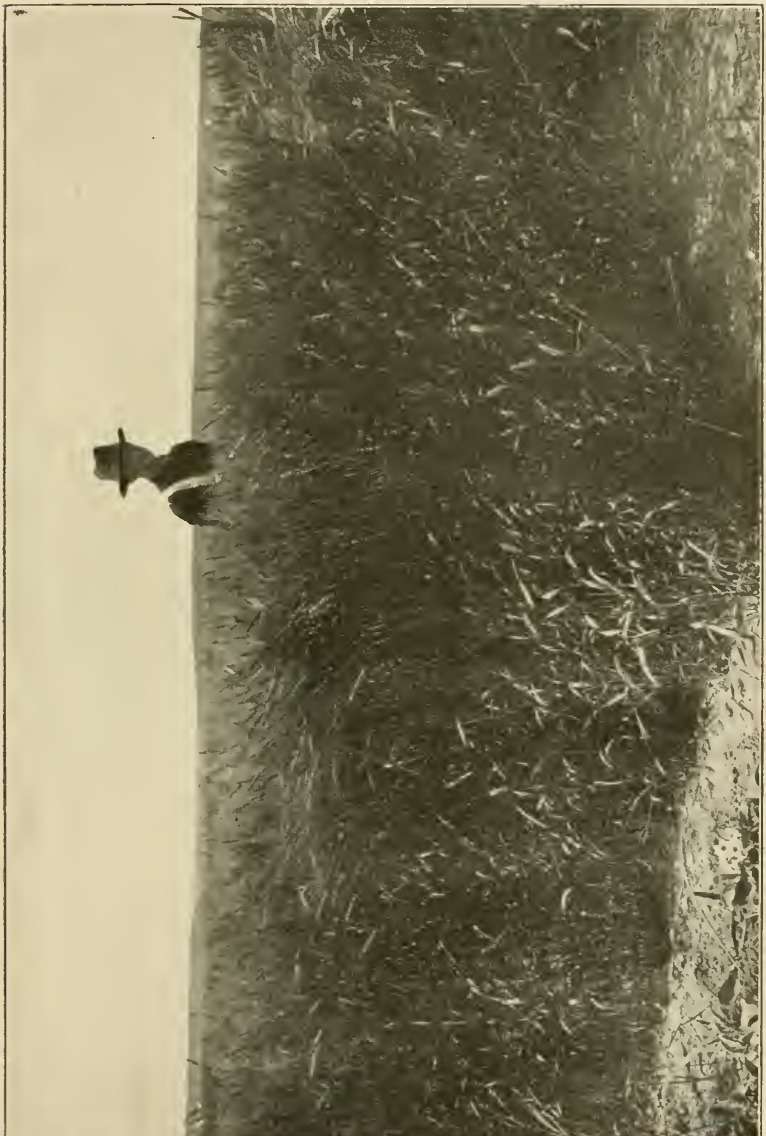

Fig 41. TURKISH RED WHEAT. FORSYTH, 1908.

FALL RYE.

While the returns from this crop have not been as large as from the fall wheat, yet yields as high as 33 bushels per acre have come when fall rye has been properly handled. The crop ought to be planted at about the same time and rate as fall wheat and handled in much the same way. The rye crop has a very strong root system and will withstand drouth conditions severe enough to seriously reduce a crop of wheat.

SPRING WHEAT.

There are two classes of spring wheat that seem especially fitted for dry land growth. These are the durum or Macaroni wheats and the Emmer, sometimes spoken of as speltz.

The Macaroni wheats, so-called because they are used in the manufacture of macaroni, were originally imported from Russia, where they had been grown under conditions of severe drouth. All varieties are heavily bearded and the grain is large and very hard. Until recently Macaroni wheat was thought to have no bread making value and was used either for feeding or for the manufacture of Macaroni products. Experiments by some of the Experiment Stations indicate that flour from Macaroni wheat makes a very superior grade of bread and it is believed will be greatly in demand for this purpose as soon as its merits are appreciated.

There are several well known varieties of Macaroni wheat grown in this country. Among the most common are the Kubanka, wild goose, yellow Pellissier and Medeah. The variety tests so far conducted indicate that the Kubanka variety, yielding upwards of 30 bushels per acre, is superior to any of the others for dry land growth in Montana.

Spring wheat ought to be seeded at about the same rate as fall wheat, three pecks per acre. The crop should be planted as early as it is possible to get the seed bed into condition in the spring.

Emmer, sometimes incorrectly spoken of as speltz, has given yields as high as 28 bushels per acre on the dry land. This crop is peculiar in that the chaff adheres to the grain, the head simply breaking up at the time of threshing. The grain is used only for feed, but as the crop is hardy, it will be found to be valuable when

feed is desired. It ought to be seeded as early as possible in the spring at the rate of about 35 pounds of seed per acre.

BARLEY.

Because of uniform early maturity, hulless barleys are well adapted to the dry farm. This class of barley differs from the ordinary brewing kinds in that the hull is knocked off at threshing time, leaving the grains bare and smooth like wheat, instead of being covered with the close fitting fibrous hull.

There are several varieties, resulting from the differences in color largely. The one most commonly grown is known as the Russian bald, or white hulless. This grows with a head entirely free from beards and has a medium sized grain, light yellow in color. This variety shatters easily and must be cut as soon as ripe, if loss is to be avoided.

The chief use for this crop is as food for animals. A small amount is used for making soups for human consumption, and in some sections this class of barley has been used for brewing purposes. Sheep feeders find very satisfactory returns when the crop is cut, stacked and fed in the straw during the winter. The threshed crop commonly yields upwards of 28 bushels per acre of grain weighing sixty pounds to the bushel.

Like the spring wheat, barley ought to be seeded as early as the ground is in condition in the spring; seeding at the rate of two pecks (thirty pounds) per acre has given the highest yields of grain with this crop.

OATS.

In looking for a variety of oats adapted to the dry land, early maturity is the one essential character to have in mind. The oat crop that succeeds under the conditions imposed must ripen in less than 90 days as a rule.

The tests so far conducted seem to show that the variety known as sixty day, which was introduced by the Utah Experiment Station, will give higher returns than any of the others tested so far. This variety has yielded as high as 63 bushels per acre and gives an average return of nearly 50 bushels.

Another variety that promises well for Montana is the Kherson,

Fig. 42. WHITE HULLESS BARLEY, FORSYTH, 1903.

an early variety introduced into this country from Europe by the Nebraska Experiment Station. This variety matures early and is a fair yielder.

Oats ought to be seeded as early as possible in the spring, using upwards of thirty pounds of seed to the acre. Up to the present some difficulty has been experienced in getting seed of the most desirable varieties. As the dry land crop area increases the supply of seed will be ample.

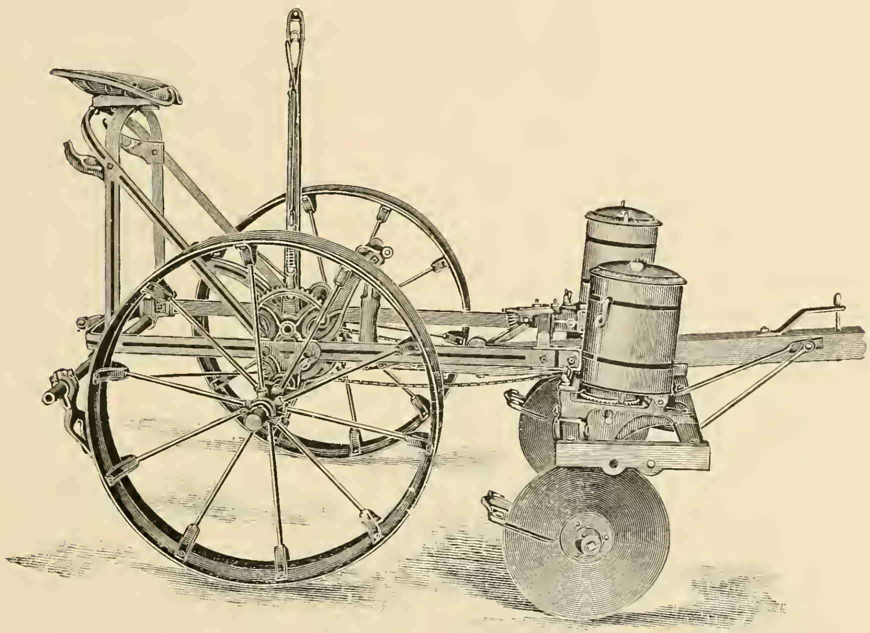

Fig. 43. CHECK ROW CORN PLANTER.

SPRING RYE.

This is one of the very hardy crops, yielding in the neighborhood of 20 bushels per acre under dry farm conditions. The crop ought to be planted as early as the ground is in condition and seeded at the rate of three pecks per acre.

CORN.

Because of the intertillage possible, corn may be grown in areas of light rainfall. Again, since this crop furnishes both grain and

forage it will be an especially valuable one on the dry farm as the feeding of live stock becomes more general.

At the present time good strains of flint corn and promising strains of dent corn are being grown in the different farming sections of Montana. Careful selection of the most perfectly matured and the best filled ears will greatly improve the corn, so that very satisfactory strains are entirely possible for Montana farmers in the near future.

Corn ought not to be planted until the soil warms up somewhat in the spring. The plant being of southern origin is used to plenty of warmth during its early growth. Planting the corn by means of a check wire planter, thus making it rowed both ways, permits of very thorough intertillage and will no doubt prove the best on the dry farm.

Corn planted at the rate of three kernels to the hill in hills 42 inches apart each way will require about 10 pounds of ears to seed one acre. This means that one bushel of average corn will plant seven acres. When the corn is shelled 8 pounds of seed per acre will be sufficient.

As soon as the corn is up so that the rows are showing, cultivation ought to begin. This is important as if the soil is permitted to become baked, the moisture will evaporate and be lost quite rapidly. Frequent cultivation is important with dry land corn.

SORGHUM, KAFFIR CORN, BROOM CORN AND MILO.

The above mentioned crops are valuable for forage and grain production in the dry areas of the southern states. Some of these are being tested in Montana at present and it is hoped that some of these valuable intertilled forage crops may be acclimated to conditions here. The crops were introduced into this country from Egypt and Africa and so find most favorable conditions in the states to the south of us.

The seed of these crops is small so that from 4 to 6 pounds is sufficient for an acre. The crop is usually sown in rows three feet apart in order that cultivation may be carried on. Until more acclimation work is done with these crops it would be unsafe to plant them in any considerable amount in Montana. It is hoped however, that strains will be developed that may be grown satisfactorily in Montana in a few years.

FLAX.

This crop is commonly grown on new breaking. It is a hardy feeder and will bring returns on land when first plowed, where other crops could not be grown.

The average yield of flax on the experimental dry farm has been nearly 15 bushels per acre. With the present prices it is questionable if the farmer can afford to grow flax extensively after his soil is in shape for the standard crops.

When the crop is grown it ought to be seeded as early as possible in the spring, using from one to two pecks of seed per acre. A growing demand for American grown fibre for the manufacture of linen may bring about new seeding requirements as well as more profitable returns for the grower.

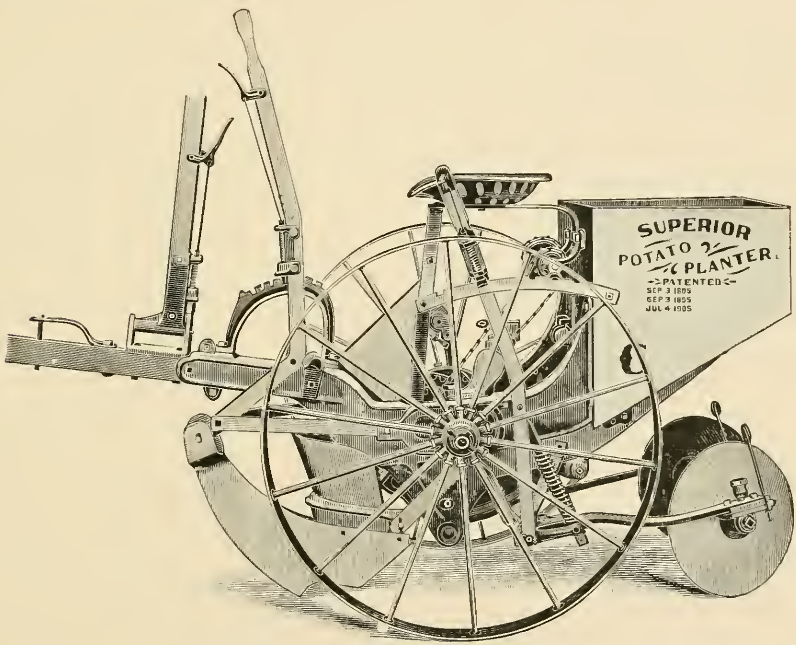

Fig. 44. POTATO PLANTER.
(Courtesy Superior Drill Co., Springfield, Ohio.)

POTATOES.

Yields ranging from 63 to 160 bushels of potatoes have been grown on the experiment dry farms in Montana during the past

three years. This indicates that potatoes sufficient for home consumption may be raised on the farms above the irrigation ditch and since the quality is very superior, points to the possibility of a very profitable dry land crop for the farmers who will give potatoes the necessary attention.

Dry land potato growing experience is very limited up to the present and it will require considerable careful experimentation before definite statements may be made regarding the best methods of growing the crop. As a result of the observations, so far in Montana, we would make the following suggestions: Potatoes ought to be planted in rows about three feet apart, dropping the tubers 18 inches apart in the row. On account of the fact that very dry soil will shrivel the pieces when the potatoes are cut, it is a safer method to plant medium sized whole potatoes and so avoid the chances of losing a crop by the pieces drying out. If there is ample moisture in the soil at time of planting this will not occur. The farmer can be guided by the conditions as he finds them.

As to time of planting very little evidence is at hand bearing on this point. As in general farm practice we believe that potatoes ought to be planted immediately after the grain crops are sown in the spring.

Thorough cultivation with the harrow before the crop comes up and later with some inter-tillage implement is an essential to success in dry farm potato culture.

SUGAR BEETS.

Sugar beets are not generally considered adapted to dry farm conditions; and successful beet culture will, most likely, be confined to a few favored localities. Sugar beets appear to be, west of the 100th meridian, a crop for irrigated lands; although, to get a high percentage of sugar, too much irrigation must be avoided. Beet seed requires a moist seed bed near the surface for its germination, and the young plants will not stand great extremes of moisture. Sugar beets require a longer growing season than most of our dry lands afford, so that the rainless period of July, August and September would be apt to prevent their filling out. After the root is well started to a good depth, water is necessary to make a profitable tonnage. Dry lands might make a very rich crop in percentage of sugar, but probably too light in tonnage to be profitable.

Notwithstanding this, E. Broox Martin of Bozeman, grew 15¼ tons of sugar beets without irrigation in 1906 and the quality was first class.

*H. W. Campbell reports a yield of 23 tons of sugar beets per acre without irrigation in Lisbon, N. D., in 1897.

FIELD PEAS.

Field peas are well suited to dry farm conditions, although experimental trials in Montana have not been numerous enough to justify very definite assertions in regard to them. It is, perhaps, unfortunate that they have not been made the subject of tests with particular reference to their adaptability to dry farm conditions, and methods of cultivation worked out in that connection. It should be borne in mind, however, that no dry farm experiments have been running in Montana for more than three or four years, means have been limited and other problems have taken precedence, so that a thorough study of the pea crop with reference to dry farm conditions has yet to be made.

Nevertheless, general principles and observations in dry farm gardens and upon scattering plants here and there upon the semi-arid lands, seem to warrant the belief that peas will do well on Montana dry lands. In the first place, the seed is large and supplied with a store of nourishment to last the young plant until its roots have made a good development. The young plants are therefore very hardy.

In the second place, peas start early and grow at lower temperatures than most crops, so that they will have made good progress in growth before the rains cease.

Third, they are early to mature and will complete their growth and ripen seeds before the pinch of extreme drouth comes on.

Fourth, their root system is very extensive and extends to a considerable depth, which enables them to take advantage of supplies of soil moisture and prevents their feeling its lack as quickly as some crops.

Peas may be drilled at intervals of eighteen or twenty inches and cultivated during the early stages of growth, and thus conserve the moisture supply.

Their value as a soil enricher is important. Among the nitro-

*Soil Culture Manual p. 219.

gen gatherers they occupy a peculiar position on the dry farm, for they are an annual and produce a luxuriant early growth, while alfalfa requires a year to get started and at least two or three years more to realize the full benefit in a rotation. Clover is too uncertain to be of much value at present on dry land. Peas, therefore, supply the need of a one year soil enriching crop in our dry farm scheme of rotation.

The uses of peas are for seed and as forage. Seed production is a business that needs to be worked out more in detail than this article permits. As a forage peas are among the richest in protein of any that we produce.

Pea vines are relished by most of our farm animals either fresh or cured into hay; but one of the best methods of feeding is to pasture them off with hogs or sheep. These animals will pick up very closely the peas that shatter and cause very little waste to the mature crop.

BEANS.

Messrs. E. and S. D. Bovee, of Cedar, in Custer county, have planted this season one hundred acres of navy beans. Messrs. Bovee have been experimenting with beans on unirrigated lands for several seasons and their experience has convinced them of the feasibility of growing beans on a large scale, with every assurance of success.

They have selected a variety of California tree bean which grows upright very large and roots deeply. The plants grow a stem the size of a man's finger and have produced 1000 beans on a plant. They are sown in drills, using an 8 foot grain drill with all but four holes stopped, after danger of frost is past in May. They are cultivated during growth to conserve moisture and kill the weeds.

Montana climatic conditions are perfect for curing the crop and insect pests are few here. We should expect therefore to produce beans of the very finest quality to be had.

If this crop proves, on more general trial, to be a successful dry farm venture, it will fill a very important place as:

A money crop;
An intertilled crop;
A soil enricher or nitrogen gatherer;
A crop adapted to the dry farm.

HAY AND FORAGE.

Among the hay or forage crops we believe that two will prove themselves to be outstanding on the dry farm. These are the alfalfa and brome grass.

Dry land farmers cannot be too strongly urged to grow alfalfa. It is an abundant producer of either hay or pasture and is one of the very best soil improvers known to the agriculturist. The crop has shown itself admirably adapted to dry land culture, so that under proper management there is no reason why it may not always be grown.

Experience has shown that it is unwise to attempt to start a crop of alfalfa on fresh breaking. During very favorable seasons crops may be successfully started under these conditions, but the farmer is taking great risk of losing his crop should the season be somewhat unfavorable for a time.

The best results have been gained when alfalfa has been planted on land that has produced at least one crop after breaking and then summer fallowed for a season. This treatment gets the sod well worked down and the summer fallow accumulates moisture to start the young alfalfa crop.

The seed ought to be sown as early as possible in the spring after the ground has been summer fallowed. Plant with a press drill, putting the seeds well down into the moist soil. Use not more than 8 pounds of seed to the acre; and in case even distribution can be depended on a less amount even down to 4 pounds has been found to give satisfactory returns. Plant the seed by itself, using no nurse crop; as when present the nurse crop tends to so reduce the moisture content of the soil as to seriously weaken the young alfalfa crop.

Do not take any hay from the field the first year. When the crop is up high enough, cut it back with a mower and leave the hay lying on the ground to protect the young root crowns. The cutting back causes the plants to root more deeply and helps to destroy the weeds.

The first spring after planting harrow the alfalfa field thoroughly with an ordinary drag harrow. Commencing the second spring double disc the alfalfa field as soon as the ground is dry enough and again immediately after the crop is removed. This cultivation forms a mulch on the surface and prevents unnecessary

loss of moisture by evaporation. When the alfalfa is desired for pasture it is best not to pasture too heavily until the crop is well established during the second year.

One possibility that promises large returns for the dry farmer is the growing of alfalfa seed. The most hardy strains of alfalfa seed are grown in the northwestern states without irrigation. These are the exact conditions under which the dry farmer is working and he may just as well have a large share of the returns from this business. During the past three years dry land alfalfa seed growers have harvested yields as high as 16 bushels to the acre. As the seed is worth upwards of $7.00 per bushel, yields averaging less than half of this amount would bring very satisfactory returns.

When the crop is planted for the purpose of seed production light seeding, not more than 4 pounds per acre, would seem advisable. Some seed growers recommend planting the seed alfalfa in rows 18 inches apart. Careful experimentation will be necessary to find out the best methods of growing the seed crop. Since good returns have been gained when the crop is sown in the ordinary way, and the first crop each season allowed to stand for seed, farmers will be safe in handling their alfalfa seed production in this manner for the present.

Brome grass is one of the most drouth resistant of all the grasses. It produces a luxuriant growth of pasture and a good yield of hay.

The seed ought to be planted on a well prepared seed bed, early in the spring, at the rate of 21 pounds to the acre. As seed is expensive a method that is sometimes followed is to plant one acre and allow it to go to seed, the first year. From this seed sufficient for a larger area may be gathered.

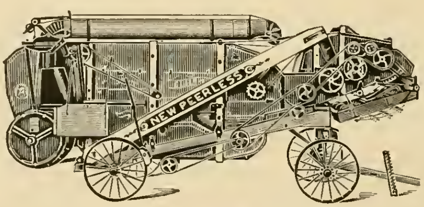

Fig. 45—GRAIN SEPARATOR.
(Courtesy of Geiser Mfg. Co., Waynesboro, Pa.)

CHAPTER IX.

CROP ROTATION.

By ALFRED ATKINSON.

Agriculturists have long understood that larger and more continuous returns are insured when crops are grown in rotation than when grown continuously on the same field. While the dry lands of Montana have not been farmed long enough to permit the effects of any system to be showing, yet past experiences under all sorts of agricultural conditions force the conclusion that continuous cropping with cereal grains cannot be practiced if satisfactory returns are to be gained on the dry farms of Montana.

Under any system of crop production two conditions arise which tend to reduce the yields. These are the burning out of the humus in the soil which brings about undesirable physical conditions, and the lessening of the supply of nitrogen available to plants. If the dry farmer can keep up the supply of humus and available nitrogen in his soil, he may look for good yields throughout the years.

Under a system of grain growing and summer fallow, which will commonly be practiced, the humus or organic matter is rapidly reduced. This material, resulting from the accumulation of the decomposed vegetation of the past, is valuable in keeping the surface soil in a friable porous condition. As crops are grown and removed and as summer fallows are cultivated this humus material is rapidly oxidized; with the result that the soil becomes hard to work, bakes readily after rains, and has very slow moisture holding capacity. Some organic material, such as barnyard manure or heavy plant roots that will decompose in the soil must be added from time to time if the necessary soil conditions are to be maintained.

Of the essential plant food elements, the one that first becomes exhausted in the soils of the Northwest is the nitrogen. This element, while existing in large quantities in the atmosphere is of no service to plants until it is incorporated in the soil and taken up by the plant roots. Crops like wheat, oats, barley, corn, potatoes, and brome grass greatly reduce the nitrogen supply in the soil

each year, and if high production is to be maintained some plan must be adopted whereby nitrogen may be added to the soil every few years.

The class of crops known as legumes, which includes alfalfa, clover, peas and beans, possess the power of taking free nitrogen from the air, and adding it to the soil for use by succeeding crops. This is done by means of nitrogen gathering bacteria which live on the roots of the plants. These organisms build up their body structures from atmospheric nitrogen and as they multiply and decay rapidly add large quantities of nitrogenous material to the soil. With this possibility existing it is evident that a cheap and effective way of keeping up the soil's nitrogen supply is to grow leguminous crops on the dry land fields at stated intervals.

As stated in the discussion under "Dry Land Crops," alfalfa is one of the surest producers that has been grown. This crop has strong nitrogen gathering ability, and possessing a strongly branched root system adds large quantities of humus to the soil whenever grown. Furnishing, as it does, these two necessary requirements, it is evident that alfalfa should have a large place on every dry farm.

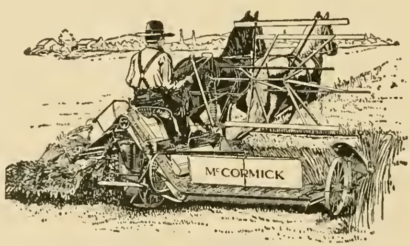

Fig. 46. GRAIN BINDER.
(Courtesy International Harvester Co., Chicago.)

Just how many years wheat and how many years alfalfa will be best is a point not yet worked out. The tendency will be to plant wheat or other grain crops continuously just as long as the yields are high enough to bring profitable returns. The farmer does well to remember that the returns from an alfalfa field are usually quite high and while restoring his soil to a state of high production, he is also getting good profitable returns from his alfalfa fields.

Where the markets are such that potatoes can be grown and

disposed of to advantage, this valuable intertilled crop can be included. Corn, which is also a valuable dry farm crop, can also be grown in most dry farming sections.

For the average dry farm, rotation consisting of two crops of grain with fallow intervening, followed by a crop of corn; this to be succeeded by alfalfa for three or four years, will be a crop arrangement that will furnish a variety of animal feed and at the same time keep the soil in good physical condition and keep up the nitrogen supply.

In this connection it may not be out of place to call attention to the importance of feeding live stock on the farm, in order that barnyard manure may be accumulated and returned to the fields. This is very important, both from a point of view of plant food and humus in the soil. The variety of crops suggested in the preceding paragraph provides for the feeding of livestock and so makes for permanency on the farms above the irrigation canal.

CHAPTER X.

THE DRY FARM AND THE RANGE.

It is not difficult to forecast a signal and permanent effect upon the livestock interests of the state from the settling up of many of the old pasture areas and the successful production of crops thereon. The prophetic vision of mortals may not reveal the specific nature of these changes, nor may the same views be held by all.

To the writer it appears that some of the ways in which successful dry farming will affect the range are:

1. Increase land values.
2. Diminish size of holdings.
3. Reduce the hazard of grazing.
4. Improve the quality of animals.
5. Change the character of the market products.

INCREASE LAND VALUES.

Under the grazing system values have been small, a few cents per acre,—a fraction of a dollar—used to cover the estimated valuation. Even such a valuation was nominal rather than actual, and actual transfers were unusual at any price.

Only as a country becomes settled do lands have a market value. Any land that produces a marketable crop worth more than the cost of production at home has a sale value. This is in the main closely related to its capacity for profitable production. Land has an intrinsic value based on fertility, or capacity to grow crops, and a place value based on proximity to market. The former is small and somewhat constant; and may be relatively high in virgin soils. The latter varies widely and is by far the largest factor. As the population increases, the markets become nearer, the land areas in a new country acquire steadily increasing values.

As the price of land advances, and interest charges on the investment mount up it becomes necessary to meet these by the sale of more valuable products. Tillage is a step in advance from the

pastoral state, and while it confers the benefit of increased values on land, it exacts a higher tribute in consequence, which pastoral pursuits cannot afford to pay.

DIMINISH SIZE OF HOLDINGS.

One of the very important effects of the settling up of a new country is to drive out the large outfits which are no longer profitable under the new conditions. Large operators are not in the stock business mainly for their health, and the greatest pleasure is coincident with generous profits. When, therefore, land values increase and interest charges begin to seriously affect the net returns, it becomes necessary to readjust the enterprise to changed conditions. These large enterprises are not so plastic and easily changed as a rule as are the smaller individual ventures. It very often happens, therefore that the simplest solution of the problem for the large operator is to sell out and settle up.

A curtailment and partial change of business is sometimes feasible and a scheme of mixed husbandry may replace the grazing business.

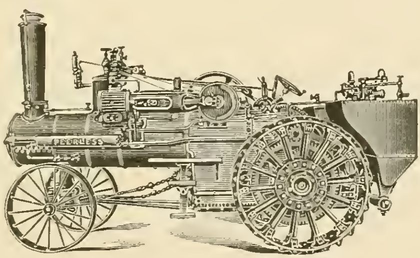

Fig. 47—TRACTION ENGINE.
(Courtesy of Geiser Mfg. Co., Waynesboro, Pa.)

It must be borne in mind that tillage lands and equipment are very much more expensive than grazing lands, and require vastly more labor for their successful development. A fixed capital will therefore be obliged to contract to a very much less acreage under tillage than with grazing. The new conditions will demand more capital or less extensive land holdings.

This effect is already becoming apparent in the closing out of many large live stock outfits formerly well known in Montana.

REDUCE THE HAZARD OF GRAZING.

The severe winter of 1906-7 was a time of fearful anxiety, loss and suffering in the grazing regions of Montana. Such conditions recur with all too brief intervals in this part of the country. One stock man told me that three times in twenty-five years he had suffered the same experience.

Losses were fifty per cent of the animals in some cases and even one hundred per cent loss has been reported. Such disasters take years of good success to repair. Losses by death are not the only ones incurred, and perhaps in the majority of cases not even the most expensive. It takes months for animals reduced by starvation and exposure to recover their normal vitality and thrift, and the season in which real growth is made is short indeed.

The quality of the market product suffers, and prices received are commensurate with the value in the market.

Animals of superior meat producing qualities, developed amid conditions of plenty, do not take kindly to a season of starvation and little progress can be made in improving the character of the livestock, where a considerable portion of the year is spent in hunger and retrogression.

As the country settles up the livestock is divided into smaller herds and bands, each nearer to its base of supplies, and under the eye of the master, the extreme hazard of loss is done away. By-products are abundant on the grain farms and animals pass the winter amid conditions of plenty. The old regime where thousands of cattle wintered on the open range at an impossible distance from even a meager supply of forage is fast passing away.

The losses by death may be practically prevented by winter forage and shelter for animals which need it, and even loss of flesh may cease to be characteristic of the winter season.

IMPROVE THE QUALITY OF ANIMALS.

Little could be expected in the way of superior fleshing qualities of animals kept under the old range system. What flesh was produced was profitable because made under very inexpensive conditions.

As the cost of production increases, owing to the higher price of pasturage better returns must be made. Winter feeding still fur-

ther adds to the cost of meat production. In order to meet this added expense a better market must be made by improving the quality of the product.

A better grade of livestock not only becomes possible under new conditions but these conditions render them necessary. Meat will be marketed at an earlier age, lessening the cost of maintenance. Better blood will be secured. Montana has indeed brilliant prospects as the home of pure bred livestock. No section of the country presents better natural conditions for the development of fine animals. The climate is dry and bracing, herbage is sweet and nutritious. Most of the snows and rains come in the spring and early summer, when they quickly disappear and do not work the hardships of severe winter storms. The forage plants are exceedingly rich and grow luxuriantly. By providing a supply of forage for the winter season, and shelter according to the necessities of good husbandry, growth and production need never be arrested from birth to final marketing.

Montana has earned an enviable reputation for the quality of cattle wherever she has taken pains to develop the right sort. Our feeders have gained distinction at the International Live Stock Exposition, and in the great markets of the world.

No locality is more favorable to the production of horses and sheep of the highest quality. Indeed, paleontology points to Montana and the adjoining states as the probable region of the origin and development of the horse group. The dry cool climate and high protein forage seems to induce the highest development of useful qualities that can be found.

Pork and poultry have succeeded perfectly wherever intelligent efforts have been directed towards their production.

With all these natural advantages for the rearing of high class livestock, it requires but the concentration of breeders upon a rational system of breeding and management to vastly improve the present domestic animals, and take a place in the forefront of the nation's progress as a livestock community.

CHANGE THE CHARACTER OF THE MARKET PRODUCTS.

Enough has already been said to indicate the trend of our livestock interests as regards the market product. Montana has been a breeding ground rather than a finisher of meat producing animals.

Growth, though rapid during certain seasons, has commonly required years for its completion. The final result of the system has been sold in the shape of stockers and feeders, or at best half fat, instead of as a finished product. Prices have ruled low when compared with those received for the finished corn fed products of the Mississippi valley; although when the cheapness of pasturage here is taken to account profits in livestock have been great.

The advent of the settler and his dry farm crops, will inaugurate a different system of husbandry which will supply the market with finished products at the prevailing prices. No longer will the market be glutted with thin to half fat stuff, but the buyers will be tempted with the ripe, juicy products that can never exceed the demand.

FIG. 48—SETTLER'S SHACK.

Besides the finished beef and mutton will be exported dairy products and pork and poultry of which the state is now a large importer.

These changes will not only increase the prices received for our

products, but will lower the cost of living, by providing more of the home grown necessities. Instead of importing bacon and butter and cheese and canned milk and eggs and poultry and vegetables and fruits, all these things will be produced locally, yielding greater comfort and better living than the range man ever dreamed of.

THE "OLD TIMER'S LAMENT.

By the Terry (Montana) Tribune Poet.

Been a trying to study it out 'bout what I'd better do—
Stay right here in Ol' Montan or just pull up and say skiddoo.
Had things fixed about to suit me 'fore this homestead crowd
came in;
Raisin' dogies was a pleasure 'fore they narrowed up the range—
But this row about the fences and this plowing up for grain
Makes a fellow think it's needful to be hunting up a change.

Thought at first it wouldn't last long and they'd soon be getting out,
But some of these here fellows seem to know what they're about.
There's some chaps up on the bench lands with some rattling crops
this year,
They keep fencing up their quarters and a plowing more and more
Spite of all a man can tell 'em 'bout how dry it is out here—
And I'll swear I don't see through it and it makes a fellow sore.

And the price of land is rising—getting scandalously high.
That school section that I'm renting and thought some day I'd buy,
Why they want fifteen an acre—more than double in a year.
Say it's worth it for potatoes and wheat and oats and rye.
And that dry land farming business is raising thunder here,
Right here in Ol' Montana where we thought it was too dry.

And so I've been a studyin' out 'bout what I'd better do—
I like it here in Ol' Montan and hate to say skiddoo.
The climate here is bully, we've got the water and the grass,
And all of us was doin' well 'fore these things come to pass,
And it behooves a fellow to be thinking of a change.
But there's no place now for dogies when they're cutting up the
range

Last spring Old Bill McKenna bought a plow and harrow, too,
Said he thought he'd try it once, just to see what he could do—
And they say he had a forty broke and put it into grain
And he got a smashing crop with a mighty little rain.
And so he's sold his bronchos and is going to farm it, too,
Just the same as these homesteaders are all starting in to do.

Wife says she thinks it wouldn't hurt if I'd give the thing a round,
But I've been kicking 'bout it so I hate to knuckle down.
And yet if Bill can raise a crop I'm pretty sure I can.
For my place is all creek bottom and his is all upland.
So sometimes I think I'll buy a plow and give the thing a try,
But you see I've always told them as how it was too dry.

And it keeps a fellow guessing, but I sure don't want to leave,
I like my bunch of dogies and it makes a fellow grieve
To be starting in on something new and breaking up his plan:
'Stead of riding to the round-ups, just be breaking up the land,
And I'll swear I can't see through it and it makes a fellow sore,
But I guess we're coming to it—no free range any more.

CHAPTER XI.

DRY FARMING VERSUS IRRIGATION.

The relation of dry farming to irrigation is complementary rather than antagonistic. The dry land farmer would gladly avail himself of additional water supplies were it possible. His attitude is that of making the best of circumstances as he finds them, and he

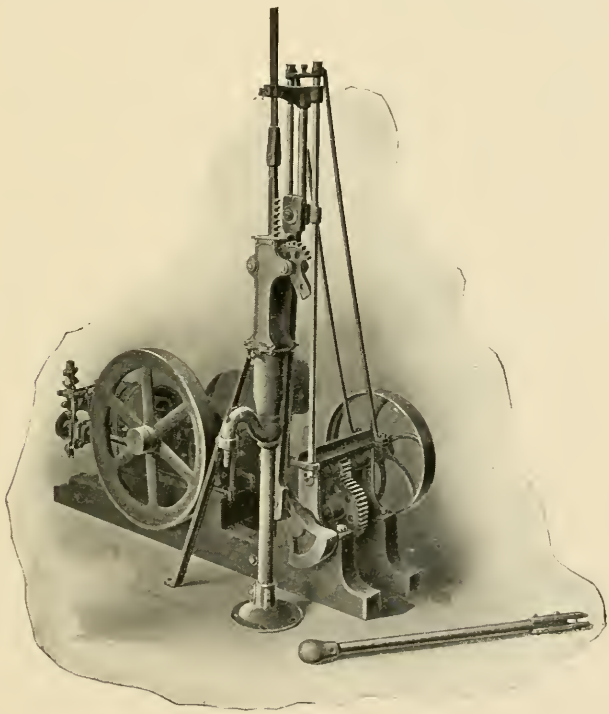

Fig 49.—IRRIGATING PUMP.
(Courtesy of Geiser Mfg. Co., Waynesboro, Pa.)

grows more and more astonished that he is able to do as well as he does.

It has been shown that only a small part of Montana lands are

susceptible of irrigation,—a matter of five or six million acres—the balance of tillable land, twenty to thirty million acres, if cropped at all, must depend upon its natural precipitation. The successful cropping of these lands forms a splendid complement to the limited possibilities of farming below the ditch.

Irrigation means intensive tillage on restricted areas. There are limitations of capital because these lands are high priced and limitations of labor because of the large demands made by intensive methods, the work of applying the water, and the heavy crop production. These restrictions are compensated by the large acre returns in product, making the handling of large areas unnecessary as well as impracticable.

On the other hand, dry farming as at present understood involves the handling of a double area. A tract under summer cultivation each season without crops equal to that upon which crops are growing. The yields are generally lighter even with the fallow method than where irrigation waters are used. The labor is also less, so that much greater areas may be annually cropped above the ditch.

Added to this is the fact that without irrigating ditches the larger, power implements of tillage are more adaptable. Plowing, harrowing and harvesting may be rapidly accomplished with a minimum of labor. It becomes possible for each man to handle a vastly greater area than he could possibly do under irrigation.

When the question comes down to the earning capacity of a man, it is an open one whether he can earn more on dry or on irrigated land.

Land areas are so great that the acre unit does not count for much here. Every man may have all he can take care of. It is not a race to see how many people can live on an acre as in China, India or Germany. How many persons can an acre support is not a Montana question, nor will it be for many years to come. The real question is "how much can a farmer earn." Give him all the land he can handle, how much can he earn? Can he earn more on irrigated land or above the ditch?

There is plenty of room for argument on both sides of this question, and there will be plenty of room for demonstration and trial in Montana for years to come. There's tillable land here for

400,000 farmers at least, ten times the present number. The questions will have to be answered by the men themselves.

The only quarrel that irrigation has with dry farming is that

Fig. 50. PULVERIZING BY STEAM POWER.
(Courtesy of Best Mf'g. Co., San Leando, Calif.)

it takes away men that might otherwise help out the irrigation tillage, and at present the men are far less than the need in either place.

CHAPTER XII.

MARKETING.

It has been urged, and not without apparent reason, that agricultural instruction emphasizes production to the neglect of favorable disposal of crops. Certainly many farmers are far more successful producers than sellers, and often a splendid crop fails to net a profit because of unfortunate sale.

No agricultural education is complete without a good knowledge of the principles of rural economics. Agricultural colleges are steadily developing this phase of training as a required study. The agricultural press devotes ever increasing space to the profitable marketing of farm commodities. It is also a subject of growing interest and attention on the lecture rostrum of farmers' institutes. A discussion of the essentials of dry land farming would be indeed incomplete were the great subject of marketing passed without mention.

While it would be out of place to devote too much space to the commercial side of the development of our agricultural resources in this chapter, there are certain phases of the question that are particularly worthy of notice, viz:

1. Concentration of exports.
2. Developing the home market.
3. Cooperative selling.

The tendency in a new country is to market very raw materials. This is an economic necessity because it is a new country. The northwest's first market products were furs. Buffalo skins obtained by practical anihilation of one of the most wonderful herds of animals the world has ever seen, were followed to market in a few years by the bones of this mighty host. So with the advent of the pioneer came the first fruits of the soil in the form of cattle and sheep. The shepherd stage of development has not yet passed away in Montana, although the succeeding occupation of grain raising is already much in evidence on many former live stock pastures.

Hay and grain have come to be important market products of

the farm and upon their sale depend the revenues of a large number of settlers. Numerous construction works of irrigation projects and railroads have afforded market for the available forage in some localities and brought the farmer the welcome ready cash. But these are for the most part transitory markets and not to be depended upon as a permanent factor in consumption.

Fig. 51. OLD ORIGINAL TYPE.

(Courtesy of Clark Horse Sales Co., Miles City, Mont.)

While the settler is obliged to take advantage of every opportunity and make the most of circumstances as he finds them, he should look ahead and shape his policy so as to best meet conditions that are reasonably certain to develop. As the country rapidly emerges from the uncertainties of settlement and takes on more of a fixed character, the farmer should prepare himself to reap the reward of a well planned system.

CONCENTRATION.

The general policy in a country remote from the centers of trade and consumption should be concentration. Avoid the tax of transportation on products of low value. Wherever possible ship only the high priced commodities upon which the transportation charge is relatively light.

To be specific: many of our cattle which have gone to the market in the shape of feeders at 4 cents or less might, by judicious feeding, be marketed at an earlier age and fat at 6 cents. The 7 cent market has been passed the current season by Montana fed

Fig. 52. MODERN RANGE HORSES.
(Courtesy of Clark Horse Sales Co., Miles City, Mont.)

steers at 7.85c per pound on foot. The same general comment will apply to Montana bred sheep, thousands of which are fed in Michigan and in the eastern states. Horses that are wild and unbroken meet with uncertain sales at low prices compared with those received for well broken classy animals.

Hay and forage, which is primarily food for animals, will bring better returns in the long run, and do far more to develop the country and lay foundation for permanent prosperity, when it is fed on the farms which produce it, than when transported long distances to the place of consumption. Where the latter system is practiced the transportation companies get the major part of the price of the forage and the farmer "gets the change."

The value of hay and forage in Montana is ordinarily from five to twelve dollars per ton. One-fourth of a cent per pound or twenty-five cents per hundred for transportation places a tax of from forty to one hundred per cent on its sale price. Concentrate the forage into meat worth four cents per pound and one-fourth of a cent transportation is only six per cent of its value. If the meat is finished to a market price of six cents per pound the transportation tax is only four per cent. If we concentrate still further to butter at twenty-five cents per pound the transportation at the original rate would be only one per cent, leaving ninety-nine per cent to the producer.

In marketing wheat it is the flour for bread making that the consumer wants. The ideal policy in marketing wheat is to market the flour and return the bran and screenings to the land after feeding them to farm animals. Thousands of tons of bran and screenings are sent with the flour to eastern points and even abroad, fattening the purse of commerce and robbing the virgin fertility of wheat lands.

That feeding can be successfully carried on is fully exemplified in the results of operations in the Big Hole region, at Billings and many other places. Mr. Geo. J. Allen of Livingston won distinguished honors at the International Live Stock Exposition at Chicago on cattle that he had fed in the Yellowstone valley.

Last spring there were thousands and thousands of tons of hay in Montana unfed and unmarketed. In the Milk River valley one town was estimated to have fifty thousand tons of hay without a market. A prominent citizen of Billings told me that he had been offered one thousand tons of alfalfa hay at three dollars per ton. If farmers would lay their plans to market their hay by feeding stock instead of depending on sale, they would receive more on the average for their forage and not run the risk of having it left on their hands.

One feeder in the Yellowstone valley makes alfalfa bring ten dollars per ton by feeding it to sheep. He can buy quantities of it of his neighbors at five or six dollars per ton.

A judicious systematic balance of the production and home consumption of farm products such as hay, alfalfa, clover, wheat offal, barley, frosted grain, pease, beet by-products, etc., will add materially to Montana's rural wealth and contribute largely to the development and permanent prosperity of the commonwealth.

ENCOURAGE HOME MARKETS.

Montana imports annually millions of dollars worth of butter, cheese, canned milk, eggs, hams, bacon, lard, etc., that can easily be produced at home. The home production of these things means the retention of wealth that is now being steadily sent abroad. In these commodities we ought to be a producing rather than a consuming state. We ought to supply these home markets and reap the reward. Prices for provisions in Montana are high as compared with other states, while the cost of production here is low. A very important economic lesson for us to learn is therefore to take care of the home market.

There are wonderful possibilities of developing the home market and consuming capacity of the state. We have unbounded resources in the way of power that have scarcely begun to be developed. The potentialities of our rivers to drive the wheels of mills and factories and electric cars are almost beyond human conception. Why should Montana be sending wool to Massachusetts and Manchester, England, to be manufactured into fabrics with her home resources of power untouched? Massachusetts is hauling coal from Pennsylvania, hundreds of miles, to develop the energy that is here already to harness.

Why send our wheat to Minneapolis and Duluth and Chicago instead of milling it at home, thus giving employment and wages to thousands of our own people? Practically all of the nitrogen and potash and phos. acid of the wheat is in the bran and screenings. In the coming years when the virgin fertility of our soils has been squandered we will rue the system that has depleted the productiveness of our land.

Why send our cattle and sheep to Omaha and St. Louis and

Chicago to be bruised and starved and subjected to market vicissitudes when every condition for manufacture of meats and animal by-products exists at home? Montana has abundance of power foi driving the wheels of great packing plants, abundance of coal for the production of necessary steam, and has the hot southern cities beaten a mile in facilities for either natural or artificial refrigeration. Why not bend our energies and enlist capital for the development of home resources and build up home markets and home consumption for our agricultural wealth?

Fig. 53. IMP. BENTLEY CONJUROR.
Suffolk Punch stallion, owned by Bitter Root Stock Farm.

Here is a wide field for the farmer, the business man, the manufacturer, and the capitalist to cooperate in the development of Montana's industries.

CO-OPERATION.

The success of many associations of farmers organized for the purpose of marketing their products bears faithful witness to their value in farm economy. The general principle of co-operation as contrasted with competition is so perfectly illustrated in the manufacturing and commercial world that the mere mention of Standard oil, sugar, steel, beef, harvesting machinery, etc., suggests the com-

bination of producers or dealers for the purpose of increasing the profits of the business.

The same principle operates in almost every town where several merchants are engaged in the same line of trade. A general understanding in regard to prices enables them to conduct their business with less friction and greater profit.

In the world of labor trade unionism is but an expression of the same idea of co-operation, and in spite of defects and errors in judgment due to human weakness and restricted vision, trade unionism has accomplished much for the betterment of the laborer's health, wealth, wisdom and virtue.

Without entering into a discussion of the ethics of combinations, trusts, or monopolies, which is too broad and intricate a topic for this publication, we may observe that they are the legitimate product of these twentieth century industrial and commercial conditions. There can be no doubt but that economy of production, distribution and management is best served by large combinations. A transcontinental railway serves the public far better and cheaper than fifty separate local roads each with only one hundred miles of track and proportionate equipment. The public would rise up and demand combination should the present continuous service be segregated into numerous small, independent units.

One reason why agriculture has failed to keep up with the progress of manufacture and commerce in some respects is the failure of farmers to co-operate. This failure is not absolute, as we will presently observe, but that it might be yet more complete is all too apparent. It has been remarked that the farmer is often a slave to his own independence. Suspicion and lack of harmony are inherent in enterprises situated at considerable distances apart. The greater the distance and difficulty of conference, the less likelihood of efficient co-operation. This explains the better co-operation in the eastern states where distances are less and means of communication more perfect.

I have been familiar with the operation of Milkmen's Protective Associations in several eastern cities, whereby customers are served with a more uniform product, at a uniform price, at a reduced cost of delivery; and incidentally are obliged to pay for their milk. A debt to one member of the association precludes their obtaining the product of another. While customers are sometimes prone to

cheat individuals they soon learn that it is necessary to deal squarely with an association. I was pleased to note that the Helena milkmen had recently formed such an association, and have no doubt that the milk dealers in other Montana cities have or will soon adopt similar measures.

Co-operation is the principle of the various round up associations that characterize the northwest. The Wool Growers' Association has been able to enhance the value of their product to its members. The Montana Live Stock Association has protected its members from frauds and losses amounting to thousands of dollars, which would have been impossible had they been acting individually.

Fig. 54. 4 YEAR OLD PERCHERON STALLION.
(Sold at Miles City, June Sales, by C. W. Green, Rock Rapids, Ia.)

The Farmers' Alliance of Gallatin valley, an organization of about 500 actual farmers, presents an example of strictly co-operative marketing of farm products.

In 1907 this society marketed, of

Hard wheat, 101,076 bushels.
Soft wheat, 50,080 bushels.
Oats, 6,500,000 pounds.
Bald barley, 2,333,000 pounds.
Malting barley, 1,000,000 pounds.
Rye, 303,000 pounds.

They actually handled about twenty million pounds of grain, selling for $300,000, but as a market factor their influence was far greater than these figures show. By strictly co-operative marketing each member received the market price for his crop less his share in the expenses. Commissions and margins were eliminated, and competing grain buyers were forced to pay fair prices. It is estimated that the average price to producers for the Gallatin valley grain crop was increased by the influence of the Farmers' Alliance from 12½ to 15 cents per hundred pounds, which would yield an aggregate of a quarter of a million dollars above what would otherwise have been paid to the grain growers.

I knew of several localities where milling companies took advantage of the absence of competition to squeeze the farmers most unmercifully. Co-operation on the part of the latter will force buyers to pay the market price.

The Flathead Farmers' Protective Association has taken care of the commercial end of a large part of the operations of its members; selling their crops, making collections, looking up the financial rating of customers, and buying implements and supplies. By handling a large volume of business it has been able to employ a competent experienced manager, conducting its affairs in a thoroughly efficient manner. Markets are found for products that would otherwise go to waste. Advantage is taken of car and train load shipping rates. These advantages are rapidly multiplied when the individual small producer is at so great a distance from the market as to preclude his going to see the buyer or the buyer coming to him.

The Bitter Root Fruit Growers' Association has been of great advantage to the farmers and orchardists of Ravalli and Missoula counties. It has an influence in the great markets of the country by its train load shipments.

They sort and grade the fruit accurately into standard quality, put up in a standard manner so that the buyer may have confidence that the brand on the package fairly represents its contents. This association has not only returned better prices to its members, reduced losses, attracted buyers to the valley, kept posted in the conditions of trade centers, and enhanced and extended the reputation of the entire region, and of the state, but it has successfully sold at good prices early and perishable fruits that could neither be sold nor shipped to advantage by individual small producers.

There are other cooperative enterprises among Montana farmers, including creameries, stock-breeding clubs, etc., but the field for organization is by no means fully occupied. Whatever is conducive to confidence and harmony among farmers deserves encouragement, and every cooperative farm enterprise increases the strength of the fundamental occupation of the race.

Labor has organized; manufacture, commerce, transportation and capital are full of combines and mergers and trusts. Then let farmers co-operate and meet numbers with numbers, pools witn pools and strength with strength.

Fig. 55. IMP. FIANCEE.
(Percheron Stallion, owned by Bitter Root Stock Farm.)

CHAPTER XIII.

FEEDING DRY FARM PRODUCTS.

That it is a sound economic principle to concentrate products to maximum values in regions remote from the centers of consumption must be apparent to every thinking man. The rough forage of Montana and probably a considerable portion of the grains will, in the majority of cases, be more profitably marketed in the form of animal products, than in their raw condition.

Successful feeding involves a judicious use of food materials to obtain the best results. Experience has taught much to the feeder in regard to the most advantageous conduct of his business. The value of individual experience is very greatly enhanced by combining the observations of many feeders. Conference with those engaged in the same line of work is fruitful of new ideas and suggestions for improved methods.

Experience supplemented by a knowledge of underlying principles is still more reliable. To understand the "why" helps one to know the "how" and "when." An acquaintance with some of the findings of the scientific study of animal nutrition should be helpful to the practical feeder.

At the outset, it is desirable to understand the meaning of certain common terms in feeding science. **Nutrients** is a term given to the components of fodders which are useful in sustaining the functions of animal life. Every fodder is made up of one or more chemical compounds that give nourishment to animals. Any compound, therefore, capable of contributing to the sustenance of animal life is termed a **nutrient.** Nutrients form simpler and more convenient units for discussion than fodders.

The principal known nutrients fall properly into three classes, viz., protein, carbohydrates and fats. **Protein** or **albuminoids** comprise the nitrogenous nutrients. They are all characterized by the presence of nitrogen in their composition which is not true of carbohydrates and fat. Certain other substances—not albuminoid—occur in fodders but for the sake of simplicity we will omit them from this discussion. The **Carbohydrates** comprise sugars, starch and

cellulose. **Fat** is commonly known under that name and need not be further defined.

FUNCTIONS OF NUTRIENTS.

Each of these three classes of nutrients has certain particular offices in animal nutrition and it is believed that each is more or less restricted to the performance of its own functions.

Protein has the broadest and most general use.

1. It is a flesh former. From it the muscles and other nitrogenous body tissues are formed. No other nutrient is capable of producing nitrogenous tissue in the animal body. These tissues are derived from protein and protein alone.

2. It forms fat. Ample proof that fat is formed from albuminoids is obtained from direct experiment, from studying its decomposition products, and from the fatty degeneration of muscular tissues.

3. It is a heat former, and by its decomposition helps to maintain body temperature and supply energy for the functional activities.

4. It is a milk stimulant. It is well known that liberal milking secretion is possible only when the food contains an abundance of protein.

Protein alone has been found capable of sustaining life indefinitely, as in case of dogs fed on lean meat.

Fat is useful in the following ways in feeding:

1. It forms fatty tissue in the body.
2. It produces heat or energy.

A pound of fat when burned in the body produces more than twice as much heat as a pound of either protein or carbohydrates.

3. It protects the protein from consumption and waste.

Carbohydrates serve the following purposes:

1. They furnish fuel for body heat and energy.
2. They protect the protein and fat from oxidation.
3. Under certain conditions they form fat.

OCCURRENCE OF NUTRIENTS.

These nutrients are found in the food materials of the farm. Protein, carbohydrates and fat are found in varying proportions in

the grasses, hays, straws, alfalfa, clover, grains, beets, potatoes, etc., that are used in feeding animals.

Generally speaking, protein is more abundant in the seed and young plant, fibre (cellulose) is found largely in the mature woody part of the stem, starch and fat in the grain and sugar in the juices. Alfalfa, clover and peas are protein feeds; corn and wheat are starchy; flax seed and cotton seed are fatty.

Digestibility. Not all of the substance of fodders is directly useful in animal nutrition. A considerable portion passes off in the solid excreta as undigested waste. Fodders vary greatly in respect to their percentage of digestibility; not only different forage plants, but different parts of the same plant, and plants in different stages of growth.

The amount of any food substance eaten which animals can digest expressed in percent is called the **digestion coefficient.**

Variation in digestibility. The percentage digestibility of a fodder is varied more or less according to the following conditions:

1. The proportion of nutrients. If starch is too much in excess of protein, digestibility is depressed.

2. Young plants are more digestible than old ones. The older plants become the less digestible they are.

3. Wetting in the field, weathering or fermenting lessens digestibility.

4. Perfect drying does not change digestibility.

5. Cooking does not improve digestibility.

6. Different kinds of animals digest foods adapted to their use about equally well.

7. Age of animals has little influence on digestibility of foods consumed.

The range of digestibility is wide. Sometimes it is very low, —ten or twenty per cent; at other times it approaches perfection, or 100 per cent. Under favorable conditions about sixty per cent of good forage is digestible. The digestibility of one fodder may be a very poor guide to an estimate of that of another. Each must be determined individually upon its own merits.

Nutritive effect should not be confused with digestibility.

Two cows consume equal amounts of fodder and keep in similar flesh. One produces forty pounds of milk while the other produces fifteen. The nutritive effect is better in the former case.

though the digestibility may be equally good in them both.

A stunted pig eats as much as a thrifty one, which gains three times as fast because in the latter case the ration produces a better nutritive effect.

Two steers in the same lot consuming equal feed, one gains one pound daily; the other three pounds. The nutritive effect of the ration is better in the second animal, though both digest equally well.

Nutritive effect is generally best at birth and gradually grows less during life.

COMPOSITION AND DIGESTIBILITY OF A FEW COMMON FODDERS*

Pounds per 100.

Fodder	Water	Ash	Composition			Digestible		
			Protein ..	Carbhyd .	Fat	Protein ..	Carbhyd .	Fat ....
Japanese millet	80	1.4	1.7	16.7	.4	0.9	10.8	.3
Corn silage	80	1.1	1.7	16.5	.7	0.8	11.2	.5
English hay	14	5.3	7.9	70.5	2.3	3.7	38.3	1.0
Rowen (2nd cutting)......	14	6.4	11.4	65.2	3.	7.9	42.2	1.4
Red clover hay	15	7.6	13.2	61.6	2.6	7.7	37.0	1.4
Alsike clover hay	15	9.7	14.0	59.2	2.1	9.2	35.4	1.4
Alfalfa	15	6.8	15.	58.	2.	10.	34.	1.2
Wheat straw	15	4.1	6.2	71.3	1.4	0.7	32.2	.4
Barley	15	4.8	6.5	71.2	2.5	1.3	39.1	1.1
Sugar beets	86	.9	1.6	11.4	.1	1.5	11.4	.1
Potatoes	80	.9	2.1	17.	.1	2.	14.8	
Barley	12	2.4	11.2	72.5	1.9	7.8	64.4	1.7
Maize	14	1.3	9.8	71.1	3.8	6.3	63.7	3.5
Oats	12	3.	12.4	69.	4.7	10.7	50.3	3.8
Wheat	11	1.8	12.4	72.9	1.9	10.	60.	1.5
Speltz	11	3.9	11.5	73.	2.2	9.	60.	1.7
Flax Seed	7	3.5	23.5	28.8	37.2	18.	22.	30.

From the foregoing it will be observed that alfalfa and the clovers are rich in protein, while English hay and the cereal straws are low in that nutrient. The grains are all very concentrated and very digestible, therefore we expect them to have a good nutritive effect, which coincides with practical experience. Flaxseed has a

*Taken from Hatch (Mass.) Experiment Station Report for 1905.

large oil content, which precludes its liberal use even if it were not too valuable for other purposes to be extensively fed.

Nutritive Ratio is the ratio between the digestible protein and the digestible carbohydrates and fat in a given ration. It is computed by adding 2½ times the fat to the carbohydrate figures and dividing the sum by the protein figure; e. g., Alfalfa contains 10. prot. 34. carb. and 1.2 fat. 1.2 times 2½ equals 3.0, plus 34 equals 37, divided by 10 equals 3.7.

Nutritive ratio is 1 : 3.7.

This is a narrow nutritive ration.

Barley straw, on the other hand, has a wide ratio, 1:32. A good average nutritive ratio is from 1:5 to 1:7 or 1:8. The nutritive ratio of 20 pounds of alfalfa hay would be widened by adding 5 pounds of barley from 1:3.7 to 1:4.8, or if we used 5 pounds of corn meal instead of barley it would be 1:5.3. This last, although a comparatively narrow ratio, is probably very well suited to Montana conditions.

Fig. 56. Shorthorn Cow VISCOUNTESS OF FAIRVIEW.
(International, Junior Champion, 1907.)

Rapid production of meat, milk or energy is favored by a rather narrow nutritive ratio, while economy of maintenance of mature animals is generally best served by a fairly wide ratio. The latter is usually obtained with less expensive fodders and less waste.

FEEDING STANDARDS.

One of the fruits of the study of feeding animals has been the fixing of feeding standards which are useful guides in the compounding of rations from fodders whose composition and digestibility are known. A feeding standard is a statement of the amounts of digestible protein, carbohydrates and fat which experience has shown to be best adapted to a given purpose. Standards have been worked out by experiment and their value depends upon the amount of experience or number of trials upon which they are based. All combinations from the richest to the poorest in varying amounts are tried and the standard is fixed at the point where economy of production is best served. The amounts of digestible protein, carbohydrates and fat which will produce prime beef at the lowest cost per pound, determine the standard for that purpose.

It should be understood that feeding standards, although stated in definite figures, are somewhat elastic. One standard will not fit all states or conditions. In a region where corn is the main crop, it would be advisable to increase the carbohydrates beyond what the standard requires. With a very strong market and a limited supply, it would pay to feed a richer ration than under average conditions.

In Montana where alfalfa, clover and peas—all protein feeds—all grow profusely, it may be policy to feed more protein than the standards call for. Even our native grasses are richer in protein than in most parts of America.

Feeding standards are expressed in terms of digestible protein, carbohydrates and fat as being much simpler than if common fodders were stated. By using the nutrients we may interchange the fodders that supply them in all conceivable ways. Any suitable fodder that supplies the requisite nutrients may be used to make a standard ration.

Following is a table of feeding standards taken from the German and somewhat abridged to suit the purpose of this article:

TABLE OF FEEDING STANDARDS.

Per day and 1000 lbs. live weight.

Kind of Animal.	Use	Dry Substance lbs.	Digestible. Protein lbs.	Digestible. Carbohydrates lbs.	Digestible. Fat lbs.	Digestible. Total lbs.	[illegible]itive Ratio 1:
Cattle	Maintenance	18	.7	8	.1	8.8	11.8
Cattle	Fattening	30	2.8	15.	.5	18.3	5.8
Cows	Milking 11 lbs. daily	25	1.6	10.	.3	11.9	6.7
Cows	Milking 28 lbs. daily	32	3.3	13.	.8	17.1	4.5
Sheep	Maintenance	23	1.5	12.	.3	13.8	8.5
Sheep	Suckling lambs	25	2.9	15.	.5	18.4	5.6
Sheep	Fattening	30	3.	15.	.5	18.5	5.4
Horses	Moderate work	24	2.	11.	.6	13.6	6.2
Swine	Brood sows	22	2.5	15.5	.4	18.4	6.6
Swine	Fattening	32	4.	24.	.5	28.5	6.3
Growing Cattle	6—12 months	27	2.	12.5	.5	15.	6.8
Growing Cattle	Yearling	26	1.8	12.5	.4	14.7	7.5
Growing Sheep	6—12 months	25	3.3	14.7	.6	18.6	5.
Growing Colts*	Yearling	25	2.5	13.2	.7	16.4	6.

* Adapted.

COMPOUNDING RATIONS.

Taking any of the foregoing standards we may compound rations, using common feed stuffs to supply the required amounts of the various nutrients. Generally the roughage or coarse fodders of the farm are used for the foundation of a ration, and grains and other concentrates to supplement these and bring the ration to the standard. Take for example a ration for milch cows giving 28 pounds of milk.

	Dry Matter	Digestible.			
		Prot.	Carb.	Fat.	Nut. Rat.
Standard for 28 lbs. milk.....	32	33.	13.	.8	4.5
30 lbs alfalfa hay	25.5	3.0	10.2	.4	
Leaving to be supplied.......	6.5	.3	2.8	.4	
4 lbs. barley will furnish.....	3.8	.3	2.4	.1	
A total of	29.3	3.3	12.6	.5	4.2

This ration approaches the standard closely as to nutrients without requiring the use of the full amount of dry substance. This is an advantage in that it requires less energy of the animal for its digestion. We have therefore used fodders that supply the desired digestible nutrients from a relatively small amount of material.

A FEW STANDARD RATIONS SUGGESTED ARE AS FOLLOWS:

Per Day and 1000 lbs. live Weight.

Ration for fattening 2 yr. old steers.	Dry Matter-	Digestible Prot.	C. H.	Fat.	Nut. Ratio.
Standard	30.	2.8	15.	.5	5.8
20 pounds clover hay	17.9	1.54	7.4	.28	
10 pounds barley straw	8.5	.13	3.9	.11	
5 pounds barley straw	4.4	.39	3.2	.09	
2 pounds flax meal (oil extracted)	1.8	.6	.7	.12	
	31.7	2.76	15.2	.60	5.9

Per Day and 1000 lbs. Weight.

Ration for wintering ewes.	Dry Matter-	Digestible Prot.	C. H.	Fat.	Nut. Ratio.
Standard	23	1.5	12.0	.3	8.5
15 pounds wheat straw	12.8	.11	48.0	.06	
15 pounds alfalfa hay	12.8	1.55	53.0	.18	
Above is sufficient for 10 sheep.	25.6	1.66	10.1	.24	1.6

Per Day and 100 lbs. Weight.

Ration for horses, moderate work.	Dry Matter-	Digestible Prot.	C. H.	Fat.	Nut. Ratio.
Standard.	24.0	2.0	11.0	.6	6.2
English hay 15 pounds	12.9	.6	4.7	.15	
Oats 12 pounds	9.8	1.3	6.0	.45	
	22.7	1.9	10.7	.6	6.4

Per Day and 1000 lbs. Weight.

Ration for fattening shotes.	Dry Matter-	Digestible Prot.	C. H.	Fat.	Nut. Ratio.
Standard	32.0	4.0	24.0	.5	6.3
50 pounds skim milk	4.5	1.5	3.0	.29	
17 pounds barley	14.9	1.4	9.2	.26	
15 pounds speltz	13.4	1.3	9.0		
	32.8	4.2	21. 2	.55	5.4

Sufficient for ten 100-pound shotes.

Profitable Feeding involves several factors. There are many times and conditions where it will not pay to feed. Where both live stock and forage have to be transported a long distance to market the cost of moving the latter may be eliminated by feeding it to the former. By feeding, from five to ten pounds of forage are concentrated into one pound of meat on foot which is capable of

moving itself a considerable distance to market or shipping point if necessary. Among the factors in profitable feeding are:

I. Suitable live stock.
II. Proper feeding stuffs.
III. Rational feeding system.
IV. Favorable marketing facilities.

Live stock should be secured with reference to its advantageous disposal. It is expected to pay out, returning full price for the cost of the animals, the food consumed, the attendance, and a fair margin for the use and risk of capital and the management of the business. Often the breeder finds it profitable to feed off, for the block, the stuff he has reared, but sometimes his circumstances are unfavorable to finishing and he is forced to sell his stock to feeders. Some feeders are so situated that it is better for them to purchase than rear their animals.

Age is an important consideration in the selection of stock for feeding. Digestion and assimilation are more active in young than in older animals. It is cheaper to produce a pound of flesh at one than at two years old. The older the animal the more feed it requires to produce a pound of gain. Other things being equal it is more profitable to feed young stock.

Fig. 57. POOR TYPE OF A STEER TO FEED.

Quality is of much consequence. Stuff of the type for which the market pays the top prices is most profitable to feed if well bought. A raw boned Holstein steer may produce as many pounds of gain with as small a consumption of feed as a thick

fleshed Aberdeen Angus but the market may make a difference of two cents a pound, or twenty-five dollars for the carcass, which vastly affects the profits of the transaction. Generally the best profits in any line come from feeding stuff of high market quality.

The Purchase Price also bears a close relation to profitable feeding. It is possible to pay too much for a good thing, but poor stuff is generally dear at any price. Feeding stock is justly lower in price than when finished, for the intrinsic value is much greater in the latter. One expects not only to market more pounds as the result of feeding, but also at a higher price per pound. His purchase must therefore have reference to the probable selling price and admit of a reasonable increase. It may cost eight to ten cents per pound to add 300 pounds to the weight of a 1000 pound steer. If so, one cent per pound advance would be required to let the feeder out even.

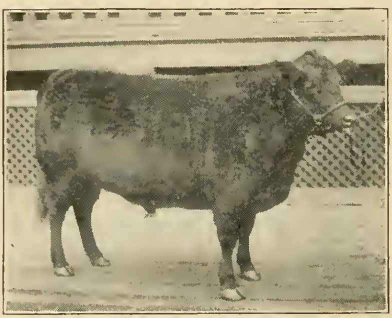

Fig. 58. INTERNATIONAL GRAND CHAMPION FAT STEER BLACK ROCK

There may be a difference in value of as much as one-half cent per pound between a lot of full steers and the same cattle shrunk out by a long drive. The condition in which they go over the scales is therefore an important factor in the price.

The feeder would make money to purchase a bunch of the right type and quality at a cent a pound over the prevailing price if the stuff could be marketed at a cent above the average because of quality. The length of the necessary feeding period also affects the purchase price of animals.

Feeds must be suitable in kind to the use to which they are

put. Cattle will not fatten on wheat straw but require more concentrated material. Store stock may be wintered on fodders that will not fatten for the block. For the latter purpose nutritious forage and some grain is necessary or at least desirable.

The quality of fodder is also of consequence. Forage that is normally good may become spoiled and worthless; on the other hand, substances may lose much of their market value without impairing the feeding qualities, as, for example, frosted grain which is unsuitable for milling but yet good feed.

The amount should be adequate to the requirements. In finishing for the block liberal feeding is essential to success. The feeder should provide forage and grain sufficient to maintain rapid production up to marketing time and not attempt to carry more stock than he can feed well. In feeding store stock, economy of maintenance is the object rather than rapid production. In any case the feeder seeks to secure the maximum returns for feed consumed.

Fig. 590. POOR MUTTON TYPE.

Feeding System. A practical knowledge of feeding methods and a scientific knowledge of foods and balancing rations is important to successful stock feeding. A suitable equipment for carrying on the work and a rational system are also prime requisites. Comfortable quarters are necessary. Animals do not thrive in discomfort. Dry sheltered feed lots should be provided and it will in the long run probably pay to protect stock from bad

storms. It has not been proved that ordinary dry cold is detrimental to success, or that stabling is desirable for meat producing animals. The labor factor has become very important of late years. Its scarcity and high price demand every facility and device possiible to increase its efficiency. The scheme that enables the attendants to get the feed to the animals with the least expenditure of time and energy should be studied.

Waste of feed should be guarded against. Feed racks that are perfect and cause the consumption of all the fodder effect a great saving in the long run. It has been found economical to have feed racks floored.

Whether feed should be kept before the animals all the time in self feeders, or should be restricted in amount, depends on many circumstances which we will not discuss here.

Recent experiments show that the maximum production is secured with a little less feed than the animal can consume. Economy dictates the most efficacious use of fodder. Mr. I. D. O'Donnell of Billings has wintered lambs in splendid shape with 2 pounds of alfalfa per day per head. He feeds once a day in the forenoon in racks with floored bottoms.

Fig. 60. GOOD MUTTON TYPE. Shropshire.

Marketing. The old maxim, "well bought is half sold," finds a close application in the feeding business. Marketing is easy when the class of goods is offered that the market wants. The feeder

should study the market and endeavor to furnish what it wants, knowing that the best returns come from stuff that excites keen competition on the part of buyers. Generally the well finished stuff of high quality is wanted while coarse and "warmed over" stuff goes hard.

The season for marketing is a problem to be considered. As far as possible go to market when others in the same line stay away. Avoid runs. By feeding, the market condition of stock can be timed to suit one's ideas and convenience and need not be a matter of chance and natural circumstances. The late summer market for range stuff is generally stronger than mid-fall. Early winter commonly sees good prices for finished fed beef. Well finished meat products are more salable at all times; but the shipper is liable to reap the benefit of a short supply in early summer. $7.85 per cwt. was paid for beef in June, 1908.

EFFECT OF STOCK FEEDING ON SOIL FERTILITY.

The virgin soils of Montana are generally rich in mineral plant food, which has been accumulating through the ages until the available supply is sufficient for many years of continuous cropping. Nevertheless, the history of the settlement of the United States from the Atlantic coast westward contains chapter after chapter writ large and plain that continuous removal of crops from the land depletes its fertility and leaves it worn out and incapable of producing profitable harvests. What warrant is there for the assumption that Montana lands are not subject to the same natural laws? Is the old plea that "posterity never did anything for us" to be again entered? In the westward tide of emigration the pinch has not usually been delayed for posterity but the first generation has felt its full severity.

The facts upon which the maintenance of soil fertility are based are the same the world over. The analyses of nearly one thousand different samples of soils* has revealed sufficient potash, lime, phosphoric acid, magnesia, etc., to supply yearly cropping without return to the land in most instances for more than a century.

*Hilgard.

The following are average percentages of plant food in soils:

Potash	.216
Lime	.108
Magnesia	.225
Phos. acid	.113
Sulfuric acid	.052
Humus	3.04
Nitrogen	.132

Taking 4,000,000 pounds as the weight of an acre-foot of soil this will give 4 tons of potash, 2 tons of lime, 2 tons of phos. acid, etc., per acre.

The arid soils, through ages of immunity from leaching have accumulated much more alkali and show an analysis of

Potash	.729
Lime	1.362
Magnesia	1.411
Phos. acid	.917
Humus	.75
Nitrogen	.101

These percentages would give for Montana soils, if these are fairly representative arid lands, 14 tons potash, 27 tons lime and 2 tons phos. acid per acre in the surface foot and probably relatively more of these substances in the subsoil than would be true of humid lands.

Fig. 61. **BACON HOG.** Yorkshire.

The humic nitrogen in arid soils compares fairly well with that of humid lands in spite of the fact that the percent of humus is only about one-fourth as great. This fact is explained by the higher percent of nitrogen in arid land humus.

The amount of plant food removed by crops may be computed on the following basis of composition in pounds per 1000 of crops after Wolff. (1).

Crop.	Potash	Phos. Acid.	Nitrogen
Spring wheat (straw)	11.6	2.	5.6
Spring wheat (grain)	5.6	9.	20.5
Winter wheat (straw)	6.3	2.2	4.8
Winter wheat (grain)	5.2	7.9	20.8
Oats (straw)	16.3	2.8	5.6
Oats (grain)	4.8	6.8	17.6
Barley (straw)	10.7	1.9	6.4
Barley (grain)	4.7	7.8	16.0
Corn (stalk)	16.4	3.8	4.8
Corn (grain)	3.7	5.7	16.0
Red clover hay	24.2	4.7	22.1
Alfalfa	25.	4.9	23.5
Potatoes and sugar beets*	5.1	.8	2.9

The total crops based on the following yields per acre would remove the amounts of fertility inscribed in the adjacent columns:

	Potash Pounds	Phos. Acid. Pounds.	Nitrogen Pounds
33 1-3 bu. of winter wheat with 2500 pounds straw	26.2	22.8	53.6
33 1-3 bu. spring wheat with 2500 lbs. straw	40.2	23.	55.
60 bu. oats with 3000 lbs. straw	58.2	21.4	50.6
40 bu. barley with 2500 lbs. straw	36.5	21.0	49.3
40 bu. corn with 2500 lbs. stover	49.3	22.3	47.8
2½ tons clover hay	60.5	11.8	55.3
2½ tons alfalfa hay	62.5	12.3	58.8
150 bushels potatoes	45.9	7.2	26.1

It is apparent that every crop removes a considerable portion of fertility from the soil, and that, the soluble or available part. Continued cropping would completely remove the total store in time, but that crops diminish and cease with the exhaustion of the available or soluble fertilizing matter. The latter may become reduced, as it has in the older settled sections of the country in a relatively short time.

(1) German.

*Sugar beets contain approximately the same K_2O; P_2O_5 and N as potatoes

By feeding these products to farm animals and returning their excreta to the land, the soil fertility remains practically undiminished. True, the beef, mutton and milk sold carry away a small percentage of mineral matter and nitrogen but these are hardly worth considering when compared with the rapid depletion resulting from grain growing.

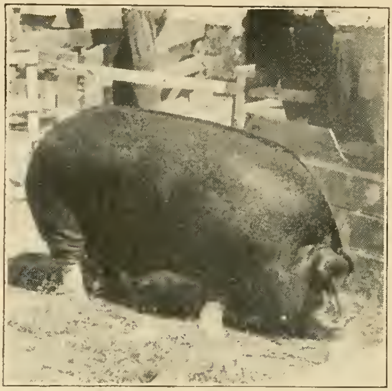

Fig. 62. **LARD HOG.** Poland China.

A general rule among agricultural investigators is to estimate four-fifths, or eighty percent, of the fertilizing matter as returned to the land in crops fed to animals on the farm. This allows a large margin for error and waste, so that practically all of the fertility of the ground is preserved in feeding the products at home.

In the long run it will be found, as it has been demonstrated over and over again in older settled sections, that farms where the crops are fed grow more productive and thrifty, while those where they are sold grow poorer and poorer. The far sighted husbandman will take due notice hereof and govern his actions accordingly.

RECORD PRICE FOR CATTLE.

FROM BILLINGS GAZETTE.

Stockmen are just beginning to realize the value of alfalfa meal and beet pulp for fattening cattle. The Billings sugar company has been feeding a large number of cattle on such feed at its feeding pens south of the city and their cattle have brought the highest price ever paid for stock so fed on the Chicago market and a much better price than has been paid this season for corn fed fancy beeves.

Two shipments of cattle have been sent to the Chicago market by the Billings sugar company this season. The first shipment, which was sold on May 18, brought $6.50 to $6.80 per hundred, while the second shipment, which was sold last week, contained 73 head, averaging 1,428 pounds, bringing $7.85 per hundred, and 141 head, weighing on an average of 1,364, bringing $7.60 per hundred. The Billings sugar company has successfully demonstrated that Montana cattle can be fed on beet pulp and alfalfa meal and be so fattened that the top prices will be paid for them. Their success undoubtedly will induce many farmers and stock raisers of the Yellowstone valley to fatten their cattle on such feed. It also adds an auxiliary industry to the growing of sugar beets that makes a sugar beet factory of more value than it has been considered to any community where it is located.

The fact that beet and alfalfa meal can be advantageously utilized for fattening cattle is a comparatively recent development and experiments in it are being anxiously watched by the cattlemen of the nation and especially those living in beet raising communities. A few more such sales as those made by the Billings sugar company and the amount of cattle fed on beet pulp and alfalfa meal will be enormously increased.

CHAPTER XIV.

DAIRYING ON MONTANA DRY FARMS.

As compared with stock raising and the production of grain—common Montana interests—dairying may be classed as intensive farming. As such it is perhaps better adapted to farms under the ditch than to those above it. There is, however, nothing in dairy husbandry incompatible with dry farming wherever a suitable home water supply is obtainable and the necessary forage for cows can be produced.

The Montana market is ample to take care of several times the present home product. There was brought into the state in 1907 over a million dollars worth of butter, cheese and condensed milk.

Not only is a large proportion of the dairy product consumed in Montana imported, but with a better supply the per capita consumption might be greatly increased. The population is also increasing at a phenomenal rate, causing a great expansion of the demand for dairy products.

Montana markets are therefore capable of taking care of dairy products to the extent of several times the present supply, and when the home market is supplied there is no barrier to an equal competition of Montana dairy men in the markets of the country. The transportation charge to a great distributing point like Chicago would be only about one cent per pound in car lots, which is a very small percentage of the value of butter or cheese.

The local price in Montana cities is the Chicago price plus transportation and commission, so that the local dairyman may be assured of very profitable returns for his products if they come up to the standard for quality.

The writer has observed that local butter, particularly ranch butter, averages low in quality, and many lots are unqualifiedly poor and unmarketable. There is, notwithstanding, no obstacle to the Montana dairyman making a product equal to that of other sections when he exercises the same care and intelligence. Butter and cheese of standard quality command a price here fully up to that of the general market.

The rapid influx of settlers from the farming states of the east is sure to give an impetus to dairy husbandry undreamed of a decade ago. Within a very few years the breeder who has for sale high class dairy stock will be in a position to take advantage of a very strong demand for cows.

As it takes at least five or six years to breed and develop a useful dairy herd, it is easy to see that it is none too early to begin. The man who starts right now to select and grade up a class of cattle along milking lines, will find that the demand for them has anticipated the supply.

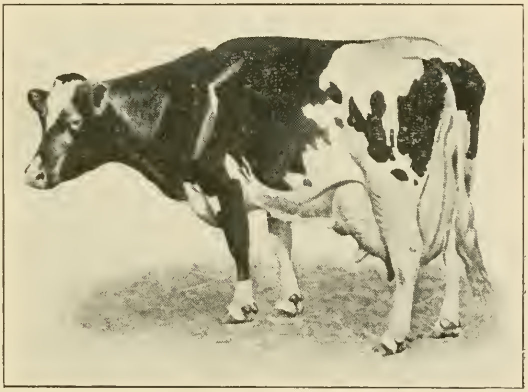

Fig. 63. AAGGIE CORNUCOPIA PAULINE. H. E. H. B. 48326.
(Record 34.32 pounds butter in 7 days. Owned by D. W. Field, Montello, Mass.)

SUCCESSFUL MONTANA DAIRYING INVOLVES:

a. Men of proper qualifications.
b. Cows of milking capacity.
c. A rational system of feeding.
d. Shelter for the dairy herd.
e. Suitable appliances and
f. Due regard for the market.

DAIRY MEN.

The successful dairyman differs somewhat from the stockman and grain farmer of the prevalent type. Dairying involves more method, greater regularity and a thorough understanding of the

peculiar technical operations of his business. The business is confining and requires daily attention throughout the entire year. Though the labor is not hard it demands rather long hours seven days a week and does not admit of a frequent spree.

Cows require gentle treatment and regular attention to do their best, and it is only by the best system that large profits can be secured. Animals left to pick their living wherever they can find it summer and winter, and milked if they happen home when the milker feels like milking cannot be satisfactory milk producers.

COWS.

The average cow on the range is absolutely hopeless as a profitable milk producer.

To be satisfactory in the dairy, a cow should produce not less than 5000 pounds (2500 quarts) of milk, testing at least 4 per cent butter fat, in a year. This is not a remarkable milk yield, although the average product for the state does not probably exceed 2000 pounds or 1000 quarts per cow per year. Annual milk yields of over 20,000 pounds have been recorded for some of the best cows of the Holstein-Friesian breed, and averages for whole herds of various breeds of from 6000 to 10,000 pounds per year per cow. The writer, when engaged in dairy farming in an eastern state, made it a rule to reject any cow from his herd incapable of producing 300 pounds of butter, or 3000 quarts of milk in a year.

Three hundred pounds of butter at thirty cents per pound is worth $90.00. There are few more profitable lines of work than dairying on that basis.

The only certain gauges of a cow's dairy capacity are the scales and the Babcock test. By use of the former, exact knowledge of the milk yield is obtained, and by the latter, its butter fat is determined. These two furnish an infallible index to the butter capacity of any cow. By their regular use, herds may be selected and the poor and unprofitable cows weeded out until a very high average profit is secured.

THE DAIRY TYPE.

While the only sure gauges of dairy quality are the scales and the Babcock test, there are certain points of conformation that are indicative of dairy excellence. The most important of the essentials

of dairy farm, without going too much into detail, relate to the udder, the barrel and general external form.

The udder should be capacious. Capacity is indicated by a long attachment to the body. In other words, it extends well up behind and well forward along the belly. It should also be broadly attached. Symmetry of the quarters, teats squarely placed and far apart are further indications of udder capacity.

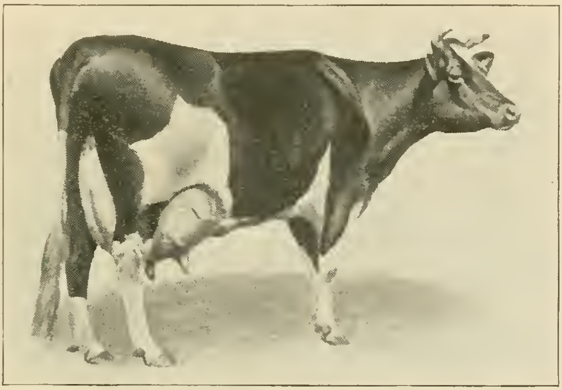

Fig. 64. DEKOL CREMELLE. H. F. H. B. 56158
World's champion Milch Cow. 119.6 pounds milk in one day. 780.6 pounds milk in seven days. .3200.3 pounds milk in thirty days. 10017.0 pounds milk in 100 days. Owned by D. W. Field, Montello, Mass.

The barrel or body should be large and long. Capacity of the barrel is indicative of well developed digestive organs, which are essential to work up the forage or raw material from which milk is elaborated. A wedge shape is generally found in large milkers. The body grows wider and deeper towards the hind quarters. A wasp waisted cow is never a satisfactory milker.

In regard to general form, it is longer and sparer fleshed than is desirable in beef cattle. As contrasted with the types of the latter, the dairy head is longer, the neck longer and more slender, the shoulders narrower and sparer fleshed, the body longer, the hips more prominent and the thighs not so full fleshed.

By selecting a few of the cows most nearly approaching this type, and grading up with dairy bred sires from large milking families, it is possible, in a very few years, to greatly increase the dairy product of Montana herds.

DAIRY BREEDS.

Very few dairy herds are to be found in Montana, and the special purpose dairy breeds are scarcely in evidence. The great majority of the cattle are reared for beef and are bred with that purpose in view. Among these the Shorthorn is by far the most numerous. While the dairy qualities of the Shorthorn have been ignored in the west for many generations, there are latent milking possibilities and very fair milkers may be selected if sufficient care and discrimination are used.

Fig. 65. LORETTA D.
Champion over all breeds, St. Louis record. 1904.—330.03 pounds butter; 5802.7 pounds milk in 120 days. (Courtesy estate of W. S. Ladd, Portland, Ore.)

The dairy breeds of greatest importance in the country are the Jersey, Guernsey, Holstein-Friesian, and Ayrshire. The first two are special purpose butter breeds, yielding the richest milk of any, the Guernsey being especially notable for the rich golden color of its products.

Fig. 66. YEKSA SUNBEAM, CHAMPION GUERNSEY COW.
Record 1000 pounds of butter in one year. (Picture taken at close of year.)

Holstein-Friesians excel all breeds in the amount and economy of milk production, and have remarkable capacity for consumption of forage. This latter fact must be recognized for they do not prove profitable unless liberally fed.

Fig. 67. COLANTHA 4th's JOHANNA. (After milking 11 months.)
World's champion butter cow. 35.22 pounds of butter in 7 days. 138.54 pounds of butter in 30 days. 1247.82 pounds of butter in 1 year 27432.5 pounds of milk in one year. Average fat test 3.64 per cent.

The Ayrshire, one of the most hardy and active of the dairy breeds, is noted for a large milk flow and good rustling qualities.

It should always be remembered that individual excellence is far more important than breed. Very poor specimens are common enough in all breeds, and the most pernicious of all scrubs is the scrub with a paper pedigree.

Fig. 68. DUCHESS OF SMITHFIELD, AYRSHIRE.
Record 190 pounds and 6 ozs. of butter from 463 3-4 pounds of milk in 7 days.

The director of farmers' institutes at Bozeman is prepared to furnish additional information in regard to the qualities of any of the dairy breeds, or of any other class of improved livestock. The scope of this paper does not permit a detailed discussion of this very important subject.

FEEDING FOR MILK.

It must be remembered that, no matter how good the cows, they will not yield a profit in the dairy unless well fed. Montana appears to be especially favored in the nutritious quality of her forage plants. Native and cultivated grasses, clovers and particularly alfalfa, are unsurpassed in nutritive properties by forage plants of any part of the country. Indeed the protein content of all these plants appears to be the highest known.

This abundance of protein in the fodders of the state has an important bearing upon the combination of rations, and obviates the need, so strongly felt in other parts of the country, of supplementing the home grown forage with concentrates rich in protein. The discussion of the principles of feeding and the balancing of rations is found in another part of this book and need not be here repeated. Two practical points in feeding dairy cows need to be emphasized, viz., a liberal food supply and a reasonably concentrated ration.

LIBERAL FEEDING.

It should be realized that the cow in full milk is using up a large supply of energy. A cow giving forty pounds of milk containing four percent of butter fat in a day is producing the equivalent of ten pounds of flesh in a growing steer. This is not created, but only elaborated from the natural raw materials which are the food consumed or the reserve tissues stored up in her body. If the latter, the supply cannot long continue. If the former, liberal feeding is essential.

It takes a certain amount of nutritive material to sustain the vital processes of the body. This is a little more with an animal in high than one in low condition. Milk secretion is only secured by food in excess of that needed to repair normal wastes. To produce forty pounds of milk daily requires therefore at least the digestible nutrients therein contained above the amount used to maintain the animal .

It would require about the equivalent of 20 pounds of good alfalfa hay to produce the 40 pounds of milk, and probably 12 to 15 pounds more to maintain a cow in good condition. The provision of thirty odd pounds of first class forage daily during the lactation period to cows in milk is something to which the average Montana dairyman has yet to become accustomed.

CONCENTRATES.

While the quality of Montana forage is so good, particularly in respect to the high protein content, as to largely obviate the need of nitrogenous concentrates, there is yet need for a certain amount of concentrated food material even in this state. The apparent reason for this is to reduce the bulk of a ration with the necessary

nutrients to the compass of the cow's capacity. Alfalfa hay furnishes all the necessary nutrients in good proportion, but to require cows to milk heavily on it alone is unreasonable because of its loose bulky nature. Some concentrated material must be used for the best results to get the bulk down to the capacity of the animal.

Fig. 69. GRAND GOLDEN LAD.
Owned by Dr. W. P. Mills, Missoula, Mont.

AMOUNT AND KIND OF GRAIN TO FEED.

It takes less concentrated fodder here than in most sections of the country to produce equally good results. Probably not over half the grain is needed in our feeding scheme that is advisable in the Mississippi valley and east. From four to eight pounds of grain with an average of about five pounds per cow daily should be found most profitable. This estimate is confirmed by feeding trials at the Experiment Station at Bozeman, and the experience of private dairymen.

As to the kind of concentrate to feed, less protein is required than in the east. The starchy grains are all good. Barley, oats, wheat and rye are suitable and better mixed than when fed separately.

The market price is a determining factor, and generally those grains of less value for brewing or milling are more available for feeding. White hulless barley, oats, frosted wheat and grain not readily marketable at a remunerative price, are in the main worth just as much for feeding as anything. A mixture of one-half barley and one-fourth each wheat and oats ground together is recommended.

Fig. 70. COLANTHA JOHANNA LAD.
Dam:—Colantha 4th's Johanna. Sire: Sarcastic Lad, Champion at St. Louis Exposition 1904. Owned by D. W. Field, Montello, Mass.

SHELTER.

That milch cows need better protection from extreme weather conditions than beef cattle has been thoroughly demonstrated by practical experience. The milk flow is seriously diminished by exposure to bad storms, very low temperature or even extreme heat; and a restoration of normal conditions does not fully restore the secretion of milk. It is, therefore, profitable to provide suitable shelter for dairy cows.

Among the most important considerations in sheltering the dairy herd are:

1. Temperature.
2. Sanitation.
3. Ventilation.
4. Economy of attendance.
5. Sunlight.
6. Comfort of animals.

TEMPERATURE.

Sudden and wide changes in temperature are prejudicial to profitable milk secretion. The stable should be arranged so that the temperature in winter may be maintained above freezing by the radiated heat of the animals. A somewhat higher temperature is recommended for milk than for meat producing animals.

VENTILATION.

A close stable without ventilation is unhygienic. Under such conditions animals become unhealthy; tuberculosis is developed and the product becomes unsafe for consumption. It is only by a continual change of the stable air, as it becomes charged with animal exhalations, that a hygienic condition is maintained. Better by far suffer the discomfort and loss due to exposure and cold than that due to disease arising from breathing foul air.

Ventilation may be had by opening doors and windows, producing drafts and lowering the temperature. Two improved systems of ventilation are in use, which have certain merits.

The Sheringham Valve secures a change of air without direct draft on the animals by means of a window hinged at the bottom and swinging in at the top, with side wings to control the air currents.

The King System involves a tight stable with no openings in walls or ceiling to interfere with the workings of the air shafts. Fresh air is admitted through the walls by ducts taking outside air a few feet below the openings in the stable, which are near the ceiling. This arrangement of intake prevents loss of heat and back draft, and provides for the gradual warming of the fresh air to the stable temperature. The bad air is removed by a shaft in the middle of the stable opening two feet from the floor which draws off the foul air without materially lowering the stable temperature.

Sanitation must be accomplished in some thorough practical way. Stables with manure cellars are not recommended for large dairies. The best plan where the dairy is sufficiently large is to remove the excreta daily to the fields, or to a compost heap at a distance from the premises.

Attendance must be convenient and effective. The arrange-

ment that makes labor most efficient in feeding and caring for animals is most desirable. Details must be worked out individually, but the general plan of two rows of cows facing towards a feeding alley is most universally favored.

SUNLIGHT.

An ideal condition admits sunlight to all parts of the stable sometime during the day. The nearest possible approach to this is desirable during the winter season. Sunshine is the best germicide.

During the hot days of summer exclusion of light keeps heat down and keeps out flies.

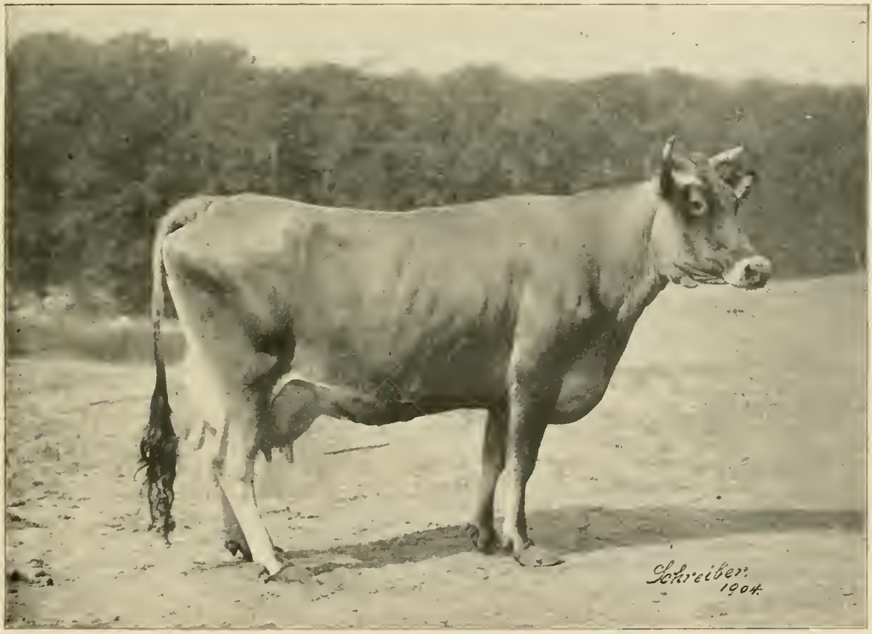

Fig. 71. DIPLOMA'S BROWN BESSIE.
Montana's butter queen. Record 17.690 pounds butter in 7 days. Member of St. Louis Model Dairy. Owned by Dr. W. P. Mills, Missoula, Mont.

COMFORT.

Cows do best when quiet and comfortable. Make the stalls commodious and dry and the ties easy. Many devices are in use, but the writer believes the chain hanging swing stanchion, the Newton tie and the Hoard stall to be among the most satisfactory. One might discuss this question at much length but such discussion is uncalled for in this article.

DAIRY APPLIANCES.

It will be difficult to carry on the dairy business even on a moderate scale without suitable room and appliances for the work. Conveniences for securing economy of labor and high quality of product are essential to satisfaction and success. With this general introduction we will proceed with the discussion of dairy equipment more specifically.

Milk Pails and Vessels. Cleanliness is the prime requisite to the production of high class dairy products. It is important therefore that milk receptacles be sanitary in construction. Experience has given the preference to tin ware with the seams smoothly soldered, precluding the lodgment of injurious germs. Sanitary pails for milking are made with hoods or restricted openings, and these may be protected with strainers of cheese cloth, thereby greatly reducing the number of bacteria that settle into the milk from the body of the cow and the air of the stable during milking.

Water Supply. A cool room, with pure uncontaminated air and plenty of pure cold water, is essential to the proper keeping of milk and cream. Water for this purpose should be at a temperature below 50° F., and better, 45°, and if the natural supply is too warm a supply of ice must be provided and used. Milk and cream keep well in deep tin vessels set into tanks with cold water coming up on the outside of the vessels as high as the milk surface on the inside. The water should always be clean and pure and needs to be frequently changed. The milk vessels should be ventilated by removing or tilting the covers, and the air of the room free from any contaminating odors.

Hot water is needed for sterilizing the vessels, and steam is a great convenience where dairying is carried on in a large way.

The best method of cleaning milk vessels is, first, rinse in cool

or luke warm water; second, wash with warm water and soap; third, sterilize with boiling water or live steam; and fourth, expose to sunshine for an hour or more.

SEPARATORS.

There is no best separator any more than there is a best plow or mower. There are several satisfactory makes, including the DeLaval, United States, Empire, etc., and one's personal preference is a safe guide. It is safer to buy a standard make with an established reputation than a new untried kind. The latter may be out of the market in a short time, and impossible to repair. Do not make the mistake of getting too small a separator. Those of large capacity cost more at the start but are more economical in the long run.

BABCOCK TESTER.

A small Babcock tester is a very desirable part of a dairy equipment, as it enables the dairyman to check up his herd and weed out unprofitable cows. It also enables him to check up his cream when sold by the pound of butter fat, and will pay for itself many times over in preventing mistakes, frauds and follies.

MECHANICAL MILKERS.

A milking machine has been perfected that has been installed in hundreds of the large dairies of the country during the past three years, put out by the Burrell, Lawrence, Kennedy company, of Little Falls, N. Y. It is not adapted to small dairies of less than twenty-five cows, and requires some mechanical sense to operate, as does most labor saving machinery.

By its use, one man, attending three or four machines, each milking two cows at a time, may milk thirty to forty cows in an hour. Cows take to it kindly, do not kick, nor hold up their milk unduly and young heifers give especially good results with it.

It milks as clean as the average hand milker, though not as thoroughly as the best man who has an interest in his cows. Stripping after machine milking is generally practiced.

Machines cost $75 each and the expense of installing a three pail plant with pump and gasoline power would be about $500.

BUTTER MAKING APPLIANCES.

Until creameries are more general in the state, butter making will have to be carried on as a part of the regular business of dairy farms. It doesn't pay to make poor butter. To make good butter easily requires some equipment. First, a tempering vat for cream is necessary. This may be boughten or home made and consists of a water tank for holding water at the desired ripening and churning temperature, into which can be set the cream to be tempered in a tin vessel. Cream needs to be thoroughly stirred when set for ripening, and there are mechanical stirrers on the market for mixing the cream during the process. (Cream ripeners.)

The churn which gives the best satisfaction is of the plain barrel or box type, of a capacity equal to the requirements of the place. It should not be more than half or two-thirds filled with cream for churning.

The lever type of butter worker is best adapted to farm dairies.

A butter printer or stamp is a very useful dairy tool where the butter is retailed in the local market.

Provide plenty of parchment paper and neat packages, for an attractive appearance counts for much in the profitable marketing of the product.

MARKETING.

Reputation counts for much in the sale of butter. It does not take long to make a reputation. If the butter maker has learned how to make a uniformly good product, he should seek a direct market, catering to customers who will appreciate the quality. It is a mistake for the beginner to contract his product for a term of years at a low price, because his first output goes slow. Sell the first on the open market for what it will bring. When the quality is secured, put your own brand or trademark on it and as far and as fast as possible deal direct with the consumer, and expect the market price when you have mastered the art of making a uniformly high class article.

A WORD ABOUT CREAMERIES IN MONTANA.

The modern habit of systematizing and promoting the division of labor has in many localities separated butter making from the

operations of the farm, and concentrated it into plants specially designed for that purpose. Several of these are in successful operation in Montana, but many others have been closed and are a source of loss to investors.

This is largely because the farmers have been gulled by outside promoters into building a creamery where no cream was produced. The promoter has no interest other than to sell his plant at a large profit and he succeeds in catching the "suckers" because they are not well informed in creamery essentials.

Generally speaking from 300 to 500 cows regularly milked nine months of the year are requisite to the successful operation of a creamery, and the more cows the greater the economy of production.

CHAPTER XV.

DRY LAND FRUIT CULTURE.

By FRED WHITESIDE.

Fig. 72. **HON. FRED WHITESIDE, KALISPELL, MONT.**
A successful fruit grower without irrigation.

As there are vast areas of land in Montana that can never be irrigated, the production of profitable crops on these lands is one of the important problems in the development of the state. In dry land farming, success depends largely upon the amount of moisture that can be retained in the land by proper handling of the soil, and this in turn is influenced in no small degree by the nature of the crop being produced. As the chief element in dry land work is constant and thorough cultivation, the crop which most readily permits the cultivation is the one most advantageous for dry farming.

And in this connection it may be said that no other crop will permit of as easy and thorough cultivation as the orchard.

While the orchard is non-productive for the first few years the land between the trees can be used for growing potatoes or other crops that can be cultivated, but this is not advisable except where the annual precipitation is considerable. Every plant grown on the land, whether it be potatoes, weeds or other vegetation, robs the soil of a portion of the moisture stored therein, and consequently clean cultivation without any crop in the orchard is by far the best method, but it is far better to grow a well cultivated crop in the orchard than to allow it to grow up with weeds. It is also of the utmost importance that the work of cultivation be started early in the spring. In fact it should be started just as soon as the snow is gone and the land is dry enough to work. As the chief purpose of cultivation is to prevent evaporation of moisture it follows that cultivation should begin before the moisture has evaporated. Cultivation will be of but little benefit if it only begins after the dry winds have blown over the land for three or four weeks. To use an old expression, "It is useless to lock the stable after the horse has been stolen." The orchard should be cultivated as soon as possible after every rain, especially if the top of the soil has been packed by the rain, for in this condition it loses moisture rapidly. But never stir the soil if it is wet enough to stick.

The amount of cultivation necessary to give the best results can hardly be stated in a hard and fast rule, but generally speaking, if enough cultivation is given to keep the orchard entirely free from weeds the trees will thrive. This rule, however, does not apply to new land for such land produces but few weeds. While no rule fixing the proper amount of cultivation can be laid down, owing to the differences in soil and other conditions, in my own experience I have found it best to cultivate the orchard three or four times each month during the entire growing season. If no other crop is grown in the orchard the work is much simplified as cross cultivation can then be practiced which saves much hard labor in keeping the weeds out.

The best tool to be used in cultivating the orchard is the spring tooth cultivator. It is five feet wide, made in two sections, eight teeth in each section. By using a long bar the two sections can be spread apart making the machine 10 feet wide. In this form a strip of land five feet wide is left between the two sections without culti-

vation. This permits cultivation of the land near the trees without driving the team very close to the trees and after going over the orchard in this manner the cultivator sections can be put together and the strips of land not cultivated the first time over can be cultivated.

Deep cultivation of the orchard is not necessary but it should not be less than four or five inches in depth. The effect of this cultivation is three fold. It puts the plant food contained in the soil in condition to be assimilated by the roots. The loose earth acts as a mulch to prevent evaporation of moisture and when the rain falls it acts as a sponge to hold the water until it can soak into the subsoil, for if the surface of the land is hard the water will run off before it can be absorbed into the soil. The subsoil acts as a reservoir to hold the water which falls upon the land and unless the surface of the land is kept loose and mellow by cultivation the water stored in the subsoil is brought to the surface by capillary attraction and is lost by evaporation. As it requires about 500 pounds of water to grow one pound of vegetation (dry) it is apparent that a very light crop of weeds will rob the soil of an enormous quantity of water which can be saved by clean cultivation for the production of the crop.

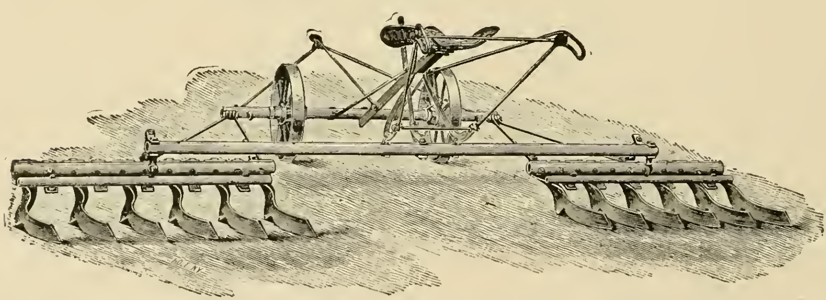

Fig. 73. ACME ORCHARD CULTIVATOR.
(Courtesy of Duane H. Nash, Millington, N. J.)

Fruit growing in the west has recently attracted wide attention because of the high prices commanded by fruit lands and the enormous profits made by growers.

Unplanted lands suitable for fruit growing in the inter-mountain region of the west are selling in many places at $500 or more per acre

while good orchards, already in bearing, can hardly be purchased at any price. This is not hard to understand because growers in many instances have received more than $1000 per acre in net returns from a single crop. Apple trees are set about 100 to the acre and usually begin bearing about the third year. The fifth year after planting the yield is usually about one box per tree and the yield should increase about one box annually per tree thereafter. Four hundred Wealthy apple trees planted in my own orchard, near Kalispell, in 1898, yielded 3000 boxes of apples in 1907. From 800 apple trees of the McIntosh Red variety planted in the same orchard in 1901, 1500 boxes of apples were picked in 1907, and at this time (May 15, 1908) the trees are loaded with blossoms for a much larger crop this year.

This orchard has never been irrigated, clean cultivation being practiced.

VARIETIES.

The question which concerns every apple grower most is, "What varieties shall I plant?" This question must be answered differently in almost every locality. For often a difference of only a few miles in location makes a wonderful difference in the varieties that can be successfully grown. There are, however, a few varieties that can be successfully grown in almost every section of Montana, and these will be first considered, although most of them, strictly speaking, are not perfect commercial apples. Most of the apples that can be grown successfully over a wide area of the state belong to the early or fall varieties, and the fact that they are not long keepers makes them unprofitable to the large commercial grower, but for the small grower, conveniently located with respect to market, they are usually very profitable. In this class are the Red June, Yellow Transparent, Duchess of Oldenburg and Red Astrachan. Of these four, the last named is perhaps the least desirable, while the Red June is one of the best. It is fine in quality, and being a dark red all over does not spot or discolor from bruising. It is not quite as large as the other varieties named, and like the Yellow Transparent, needs severe thinning. A most serious objection to the Yellow Transparent is its tendency to spot under the slightest bruise, and this objection also holds in less degree against the Duchess, and in fact against all yellow apples. Other early ap-

ples grown successfully in places, but not yet widely distributed, are the Gravenstein and Benoni. While the foregoing are called early apples, the date of ripening varies greatly with locality and altitude. Other apples grown successfully in almost every portion of the state are the Snow, Alexander, Wealthy, McMahon White and McIntosh Red. These ripen very close together in point of time, and in some places the last four are called Fall apples, in other sections they are Late Fall or Early Winter apples. As a rule apples ripen later and keep longer east of the Rocky Mountains than do the same varieties west of the Mountains, and in this respect the Flathead Valley is somewhat later than points south on the same side of the range.

The Alexander is one of the best fall apples grown in Montana. It is very large, of fine appearance, color red and yellow, and of fair quality. The Snow is of about the same season as the Alexander, much smaller, but of very fine quality, red in color

Fig. 74. 9 YEAR OLD WEALTHY APPLE TREE.
(400 trees produced 3000 boxes of apples in 1907.)

with some green. The Wealthy is perhaps the most widely distributed apple in the northwest and in many respects is one of the best. In localities where it ripens late it may be classed as a

good commercial apple, but where it ripens early it is not as good, because it does not keep as well. Where it ripens early it is inclined to fall from the tree and begins to wither in two or three weeks after picking, even in the best of cellars. Its color is red, with some green, quality fair, size good. The McMahon White is of about the same season, size and keeping qualities as the Wealthy and is fine for cooking. All things considered, the McIntosh Red is perhaps the best commercial apple widely grown in Montana. While in a few sections the tree has not been considered entirely hardy, yet losses from winter injury have not occurred in the coldest sections where the trees are grown,, and such losses have probably been due to local conditions. The apple is of the finest quality, and has a spicy flavor peculiar to itself. It is of good size, dark red in color, and keeps until about January first, although like other apples, its keeping qualities vary with the date of ripening in different sections. The tree is of good shape and a very vigorous grower.

Of the varieties mentioned, the Yellow Transparent and Wealthy are the most prolific bearers, with the Red June a close second. The others are good bearers but cannot be depended upon to produce a full crop every year. The reason for light crops, however, is usually to be found in a lack of cultivation, pruning, thinning or other necessary work.

Fig. 75. 6 YEAR OLD RED MCINTOSH ORCHARD.
(800 trees produced 1500 boxes of apples in 1907.)

Apples should be thinned to one in a place, and these not closer than five inches apart on the limb. To accomplish this, it is often necessary to remove four-fifths of the crop; but measured in pounds the matured crop will be fully as large as if no thinning had been done, and instead of small second class apples the product will be large, first class apples. Thinning should be done as soon as possible after the apples are formed. Fruit growers often complain about the excessive labor and cost of thinning but it requires no more time or labor to take the extra fruit off in the spring than to pick the small apples in the fall.

CRAB APPLES.

When grown on a commercial scale, one of the most profitable fruits in Montana is the crab apple. When produced in less than car lots, however, the grower must depend on local demand, which is usually unsatisfactory.

Crabs can be grown successfully in every section of Montana and the risk from winter losses is very slight.

For market the best variety is undoubtedly the Transcendent, and for this variety in car lots the demand is almost without limit, the price usually being from $1.00 to $1.25 per box f. o. b. Montana points. Other varieties grown are the Hyslop, Martha, Gibbs Golden, North Star, General Grant and Whitney No. 20, the last named being as large as the ordinary small apple, and is delicious for eating out of hand, but is very short lived. None of the crabs, however, are long keepers.

PLUMS.

Plums are grown successfully all over Montana but some varieties can only be grown in favored places.

From the standpoint of profit, plums are perhaps the most unsatisfactory of all the fruits grown in the state. This is not due to any lack of quality or productiveness, but to the poor methods of packing, inadequate transportation facilities, and the perishable nature of the fruit.

The Bradshaw, Moore's Arctic and DeSoto are among the hardiest varieties grown. The Wyant and Forest Garden are reported from the Experiment Station at Bozeman as being very hardy.

Other varieties successfully grown in more favored places are The Lombard, Yellow Egg, Green Gage, Peach Plum, Tragedy, Pond's Seedling, Italian Prunes, and German Prunes.

CHERRIES.

All things considered, cherries are among the most profitable and satisfactory fruits grown in Montana. While the trees are not as hardy nor as long lived as the apple or crab, the hardy varieties can be grown in most sections, and west of the main range the cherry is a standard crop. The demand for the fruit is almost unlimited, and the price received by the grower is from eight to ten cents per pound.

Sweet cherries are produced very successfully in certain sections of the Bitter Root and Flathead, but cannot be grown in all sections, as the trees are not entirely hardy, and even where the trees grow, do not always fruit well, but where the sweet cherry can be grown, it is highly profitable. Of the sweet cherries, the Bing and the Royal Ann are the varieties most widely grown. The Bing is perhaps the favorite, being a large, dark red cherry of fine quality. The Royal Ann is equally large, but lighter in color. The Lambert is also grown successfully in places.

The sour varieties of cherries are much more widely grown than the sweet cherries, and are prolific and regular bearers. Of these the Early Richmond, Valdimir and Ostheime, are perhaps the most hardy, with the Montmorency, English Morello and Wrag close up in point of hardiness. Of all the sour cherries the Montmorency is probably the favorite, being a little larger than the Early Richmond and not as sour as the others.

The Wrag, English Morello and Ostheime are dark red in color and are splendid for making wine.

BEST AGE TO PLANT.

In orchard planting most growers of experience prefer trees not more than two years old from the nursery, and many orchardists plant yearling trees with very satisfactory results. The future growth of a tree is retarded by transplanting in proportion to its age and if trees from one to four years old are planted at the same time, in the same soil, and are given the same care, in a few years the

younger trees will be larger than the older ones. For this reason young trees are preferred for planting.

PRUNING.

When the tree is planted, the top is generally cut back to make it balance the root, as the roots are cut severely in digging the tree. The best practice, however, is to reduce the top by cutting out the superfluous limbs. This will give the tree proper shape and will force the growth into limbs that are to form the permanent top of the tree. There is much difference of opinion as to the proper shape for a tree, and particularly the apple tree. The growers of most experience, however, have no fixed rule for shaping or pruning the tree, each tree being treated acocrding to its requirements. If a tree is a very upright grower, the inside branches are cut out to make a tree more spreading. If it is very wide and spreading, the outside branches are cut off to make it more upright. The ideal form which most growers endeavor to reach, is an urn-shaped tree, with the trunk dividing into three or four main branches about two or two and one-half feet from the ground, these three or four branches forming the entire top of the tree. The main branches should start out at nearly right angles to the trunk, and curve upward, which will obviate the danger of the tree splitting down. This danger is further provided against by twining together two of the small inside branches from opposite sides of the tree. These will grow together, and form a solid tie across the tree, and if the tree has four main branches there should be two of these ties fastening the opposite main branches together. A tree that is properly shaped when planted will require no pruning, except to keep the suckers and small limbs trimmed out, and this should be done at least once a year. Winter or early spring is the best season to prune, as the trees are then bare of foliage, but most growers avoid pruning when the wood is frozen. If a tree is planted with a large number of branches, these must be cut out from year to year, and much of the energy exerted in growing wood is thus wasted.

CHAPTER XIV.

THE DRY FARM GARDEN.

Far too generally and for too long a time the opinion has been held that gardening is an impossibility on semi-arid farms. Enough of successful experience has been obtained during the past few years to prove that many varieties of vegetables, truck and small fruits can be grown without irrigation in a very high degree of perfection.

Fig. 76. SQUASHES, Forsyth, 1907.

Northwestern farmers and ranchers have become so accustomed to canned stuff that they do not appreciate fruits and vegetables coming fresh from the garden, or else they are too indolent to exert themselves to provide these home grown supplements to the family bill of fare. This is not a condition peculiar to Montana or the

ranch home, although the owner here may entrench himself behind the belief that crops will not succeed without more rainfall. It is characteristic of farmers as a class the country over to neglect the garden. The garden is often the weediest spot on earth. A man may be a very thorough and successful farmer and pay little attention to the production of kitchen vegetables. His time may be fully occupied with those things that return more money for the efforts expended, so that in his judgment it is cheaper to buy vegetables than to raise them. The farmer is not so well situated to buy as people who live in town, with well stocked markets, yet even townspeople are continually served with truck which has suffered deterioration and is very inferior to that coming to the kitchen and table fresh from the garden.

As a rule the farmer who argues with his conscience or his wife that "it is cheaper to buy vegetables than fuss with a garden" experiences the luxury of going without.

It may be futile to attempt to convince the husbandman that it is worth while to start a garden on his own initiative, but if this should by chance catch the eye of his wife or housekeeper, she will know how to bring about the desired results.

The Montana farmer is rapidly changing his idea of the farm as a place to make money, in order to live and spend it elsewhere, to the better conception of it as a permanent home where he may live the fullest possible life. To this end he is building more comfortable and convenient houses, beautifying their surroundings, taking pride in the artistic and harmonious effect of the arrangement of buildings and grounds, providing for regular mails, installing telephone connections with his neighbors and the town, improving the roads and building school houses; in fine, those things that minister to the comfort and happiness of the man and his family and promote their social, intellectual and moral development are supplanting mere money getting as the chief object in farm life.

A very good criterion of life is the living expressed by the food which goes on the table. Where this is abundant, in good variety, well cooked and tastefully served, at least one phase of the standard of living is high. Nothing contributes more liberally towards variety in food than a perennial supply of standard vegetables. The supply of these on the farm depends upon its garden.

It is certain that many of the common vegetables may be grown

on the unirrigated bench lands of Montana which are being rapidly settled up by homesteaders. We have seen growing luxuriantly radishes, lettuce, peas, beans, cabbages, beets, sweet corn, tomatoes, melons, pumpkins, squashes, onions, etc., in gardens where neither scientific planning nor dilligent attention were at all conspicuous. Such proof must convince the intelligent farmer or at least his more intelligent wife that where thoughtful planning and dilligent care are bestowed the garden will add much to the comfort, yea even the luxury, of farm life.

Fig. 77. MELONS, Forsyth, 1907.

GARDENING METHODS.

Dry land experience indicates the importance of:

1. Alternate crop and fallow.
2. Correct method in planting and
3. Frequent surface tillage, to successful gardening without irrigation.

It will probably pay where land is plenty and cheap to cultivate a double area in garden. One-half to be cropped each season, the other half to be summer tilled without a crop. By this system a maximum moisture can be stored in the soil, so that each spring the seeds go into the ground under most favorable conditions. Having the uncropped portion all together will facilitate its easy tillage by horse power. This portion may be manured during the fallow year, to increase its store of humus and its moisture holding capacity as well as its fertility, thus gradually increasing its productiveness and moisture content. In the semi-arid regions loss of fertility by leaching is not to be feared.

PLANTING THE GARDEN.

Many garden seeds are extremely small and do not contain stores of nourishment sufficient to sustain the young plant for long. Its life, therefore, depends upon its quickly getting hold of the moisture and dissolved plant food in the soil. Even hardy plants, coming from larger seeds containing stores of nourishment sufficient for many days, start better and make a more vigorous growth where soil conditions are just right.

It is important in planting garden seeds to have a perfect seed bed. The subsurface soil should be free from large air spaces and bunches of dry organice matter. It should be sufficiently compact to admit the upward movement of capillary water to the seeds and young plant roots from below, and should be covered with a mulch to keep this moisture from escaping into the air by evaporation.

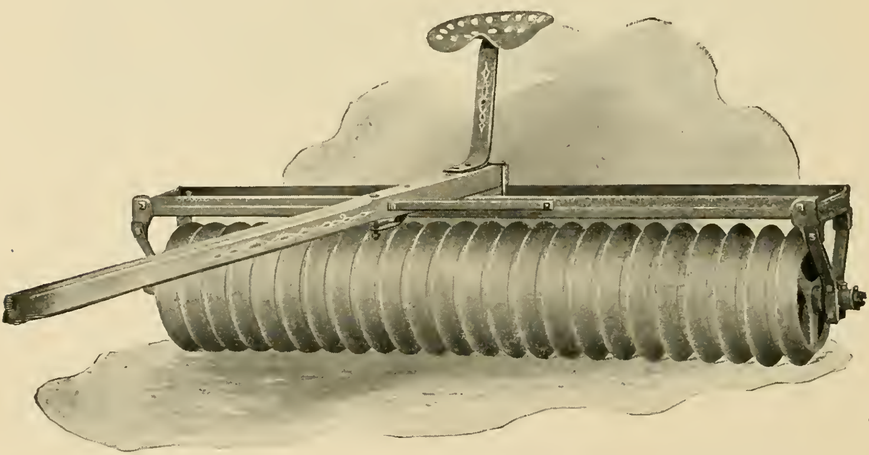

Fig. 78 SOIL PACKER.
(Courtesy of J. W. Dunham, Berea, O.)

The seeds should be put into the moist earth, and the soil firmed about them, in depth from one-half inch upward, according to the size of the seeds. After packing the seeds in the moist soil, from half an inch to two inches of loose dry earth should be spread over to hold the moisture in. If this method is carried out in planting and other principles of moisture conservation adhered to, there should be no failure of good growth of vegetables.

Tillage must be frequent enough to prevent a crust from forming and under no circumstances must weeds be allowed to grow, for they rob the land of the moisture which it is our chief purpose to retain.

The cropped portion of the garden must also be tilled frequently to maintain the moisture holding mulch and prevent the growth of weeds. Tillage here involves the regular use of the hoe and cannot all be done with the harrow by horse power. A horse garden cultivator may be used to good advantage where the vegetables are judiciously planted in drills or rows.

Most garden vegetables grow quickly and their production, where grain crops succeed, is reasonably certain. They have the advantage of summer tillage by means of which the maximum benefit is derived from the moisture in the ground. That most of the common vegetables can be grown without irrigation is fast becoming a matter of general experience, and the list for dry land planting is being rapidly extended.

Many of the bush fruits, such as currants, raspberries and gooseberries may be planted in full expectation of a delicious harvest, and strawberry plants may be so managed as to furnish a bountiful supply of that most delicious fruit.

The ornamental shrubs and flowering plants should not be neglected. In a region where the wild rose grows in such profusion and wild flowers flourish, one need not be denied many of these plants which go to beautify the home.

It may prove feasible in many instances to prolong the season for fresh garden vegetables by artificial watering. A spring may furnish water for this, or a well and wind mill with a large tank, so that the vegetables, flowers and grass on the lawn may be watered when the natural water supplies fail. This can be accomplished at a small expense when compared with the incalculable benefit derived.

It should be borne in mind that when this watering is begun it becomes necessary to continue it. Generally economy will dictate the postponement of artificial watering until crops show unmistakable signs of need. Do not neglect tillage, and the conservation of soil moisture; and after each irrigation cultivation is necessary to give the ground the full benefit of the added water. By means of a little artificial watering, the list of plants and shrubs may be extended to take in about everything that temperature does not exclude.

Dr. W. X. Sudduth writes concerning results at Broadview. "The garden truck was all that could be asked. All kinds of garden stuff did exceedingly well. We had all the radishes, lettuce, onions, peas, beans, carrots, parsnips, beets, turnips, cabbage and summer squash we could use at headquarters all summer. No one need go hungry if he will bestir himself and till his garden sufficiently."

Fig. 79. SETTLERS.
(This shanty will soon give place to a fine farmstead.)

CHAPTER XVII.

PLANTING THE HOME GROUNDS.

BY PROF. R. W. FISHER.

There are many reasons why farmers throughout the state of Montana should give more attention to the improvement of their home grounds. There is probably no state in the union where so little attention has been given to ornamenting the farm homes, and this chapter is written with the hope that it may influence some, by pointing out the way, to plant a few ornamental trees, shrubs, and flowers.

In the so called dry land farming sections of the state where water from an irrigation ditch is not available, special care must be taken in the preparation of the soil before planting time and in the manner of growing the plants.

This preparation of soil should begin at least the fall before the plants are to be set out, and preferably one year before planting in order that all the moisture possible may be retained in the ground to carry the plants through the first season.

The land where the plants are to be set should be plowed from 8 to 14 inches deep in the fall and left without cultivation until the following spring. This puts it in such condition that all the moisture which falls has a chance to soak into the soil. As early in the spring as the ground is dry enough to work, it should again be cross plowed and then thoroughly disked until the surface 3 inches is finely pulverized. By harrowing with a disk several times, following with a smoothing or drag harrow, the surface soil can be put in excellent condition. The fall plowing can be done during the months of August, September or October, and the spring cultivation done usually in March or April.

The success of growing ornamental plants depends very much upon the preparation of the soil and great care therefore should be taken in this preliminary work. In parts of the state where the snow drifts badly or is likely to be blown away, a snow fence a few rods on the leeward side of the place to be planted to ornamental plants will serve to collect snow and thus increase the water supply

in the soil. Good illustrations of snow fences and their action on drifting snows may be seen along the several railway lines in the state.

All plants which have to be shipped in from a distant nursery should be ordered in the fall or winter for early spring delivery. Young plants are likely to give best results as they are more easily transplanted and will adapt themselves to changed conditions more readily than older plants. Ornamental trees one or two years old, which have been once or twice transplanted in the nurseries are the best for the general planting, as they usually have a good, strong, compact root system and can stand transportation and transplanting much better than seedling trees, or trees 4, 5 or 6 years old.

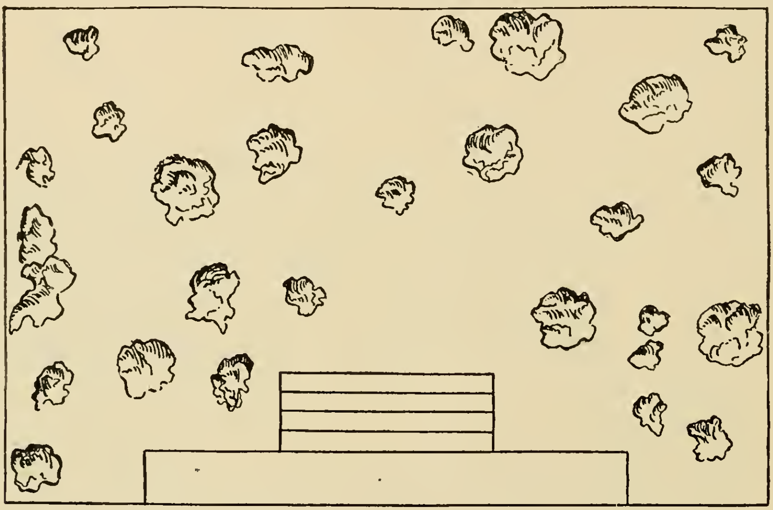

Fig. 80. PLANTED BUT NOT PLANNED.

The same grade of ornamental shrubs should be ordered, that is, young plants that have been transplanted at least once in the home nursery. Such plants usually cost a few dollars per hundred more than do the seedlings, but the results are so much better that the difference in price is more than made up in the increased growth and low percentage of loss.

The best results are obtained when the young stock is purchased and grown in nursery rows for one or two seasons and then planted into permanent places. Young trees one or two years old from seed,

and once or twice transplanted, can be purchased from large nurseries for a few dollars per hundred; while trees large enough to plant out into permanent places would cost much more and not be as likely to live. The nursery ground should be prepared by the deep fall plowing and thorough spring cultivation as before mentioned. In the spring when the plants arrive and the weather and soil are suitable for planting, furrows 3½ feet apart and 12 to 14 inches deep can be plowed where the plants are to be put. The roots of the small plants are then put in this furrow and covered with fine, moist earth which should be firmly tamped down, afterwards the surface soil is put in and left loose. These trees should be cultivated once every week from planting time until about August 1st, when cultivation should stop in order to make the plants mature their wood. By this thorough cultivation enough moisture can be retained in the soil to carry the plants through without irrigation.

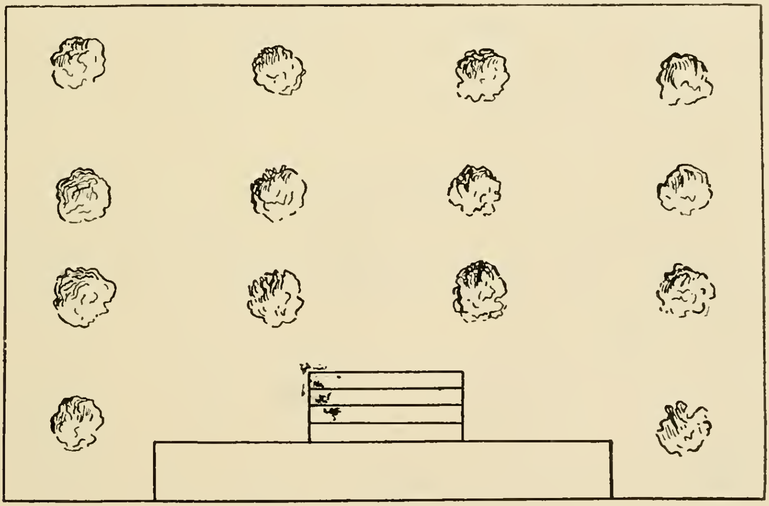

Fig. 81. GEOMETRICAL.

After the plants have been grown in nursery rows for one or two seasons, they will be large enough to plant out in the yard or upon the lawn, or if they are of suitable varieties and properly located part of them may be left for a shelter bed or wind break, and cultivated until the tops are large enough to shade the ground.

The same care should be taken in preparing ground for planting trees where they are to stand alone, unless it will be possible to water them from a bucket until such time as the roots have become well established and found permanent water.

By watering trees about the home for two or three years with a bucket, they will develop a root system large enough to get water from the subsoil after which hand watering will be unnecessary. In any instance the soil about the trees should be kept finely pulverized and cultivated after each rain or irrigation in order to conserve all the moisture. The holes for trees to be planted out on the lawn, should be sufficiently large to receive the roots without crowding them out of their natural position and deep enough so that the tree may be planted a trifle deeper than it stood in the nursery.

Fine moist earth should be worked in around the roots and packed down hard, leaving the surface soil loose so as to shut off evaporation. If it is not possible to cultivate or hoe the trees every week or ten days, a mulch four to six inches deep of coarse manure or straw is good to place about the trunks of the trees to prevent evaporation. If possible, the trees should be watered from a ditch or bucket several times during the first and second years after which time with good cultivation they will be able to care for themselves.

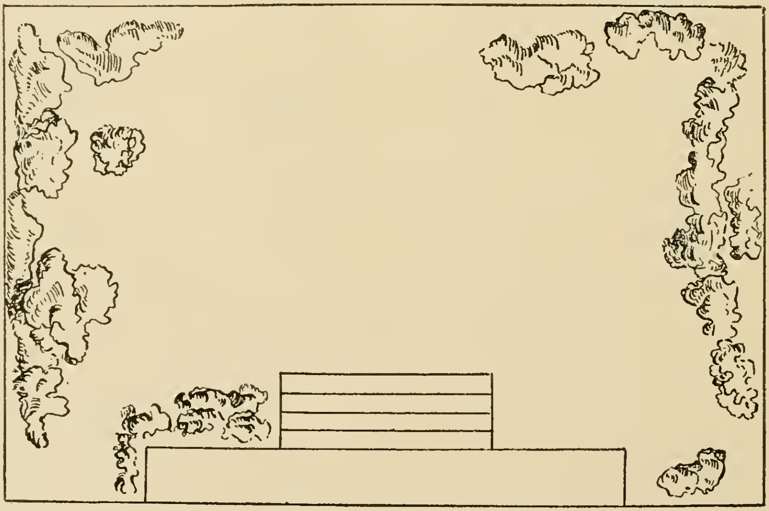

Fig. 82. RESULT OF DEFINITE PLAN.

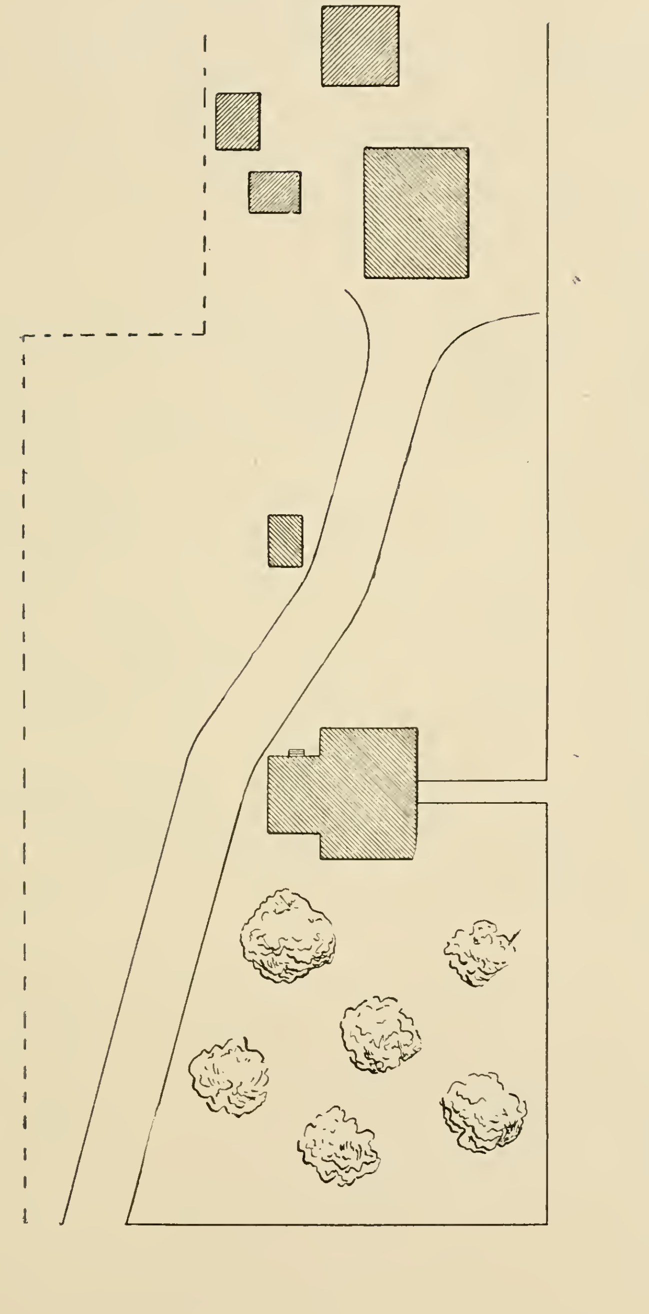

Fig. 83. ORIGINAL PLAN OF GROUNDS.

Before any of the plants are set out a careful plan of the grounds should be made, showing the location of all buildings, roads and foot paths. The location of the trees, shrubs and flowers can then be platted on the map to harmonize with the building and roads. It is impossible in an article of this kind to give specific directions regarding the location of ornamental plants, but we can point out the general rules, which if followed, will result in pleasing effects.

Roads and foot paths should be located where they will be most used. As a general rule the shortest distance between points will determine the location, although slight curves add to the beauty of a driveway. This necessity for curves may be made by planting groups of trees or shrubs in direct line between two points and curving the road so as to go around the group. Unless there is some visible reason, either natural or artificial, for having a road curved, it is best to make it straight; otherwise people would cut across corners and in time establish a straight road or path.

The most pleasing effects in planting trees and shrubs on the lawn are obtained when the plants are placed in groups about the borders and in the curves of driveways, leaving the center of the lawn open. The plants about the borders can be so placed that distant views may be preserved, and unsightly objects hidden from vision.

A few trees of strictly ornamental character may be placed about the house and small shrubs planted in corners or angles. The flowers are planted along the borders in front of shrubs or trees and in angles of roads or paths, or in borders next the house. Formal flower beds in the center of the lawn are not in harmony with good artistic taste.

The plants suitable for planting on the dry farms in Montana are not very numerous unless water from a well is available. This water may be applied by carrying it in buckets or if a windmill is on the place watering can be done by running a ditch or preferably a small flume from the windmill pump or cistern to the plants. One or two good irrigations during a season with surface cultivation will be sufficient to grow good plants.

Among the trees for planting along borders and in groups are Canadian poplar, Norway poplar, silver-leaved poplar, white willow, American elm, box elder, Norway maple, Balm of Gilead, etc., and at

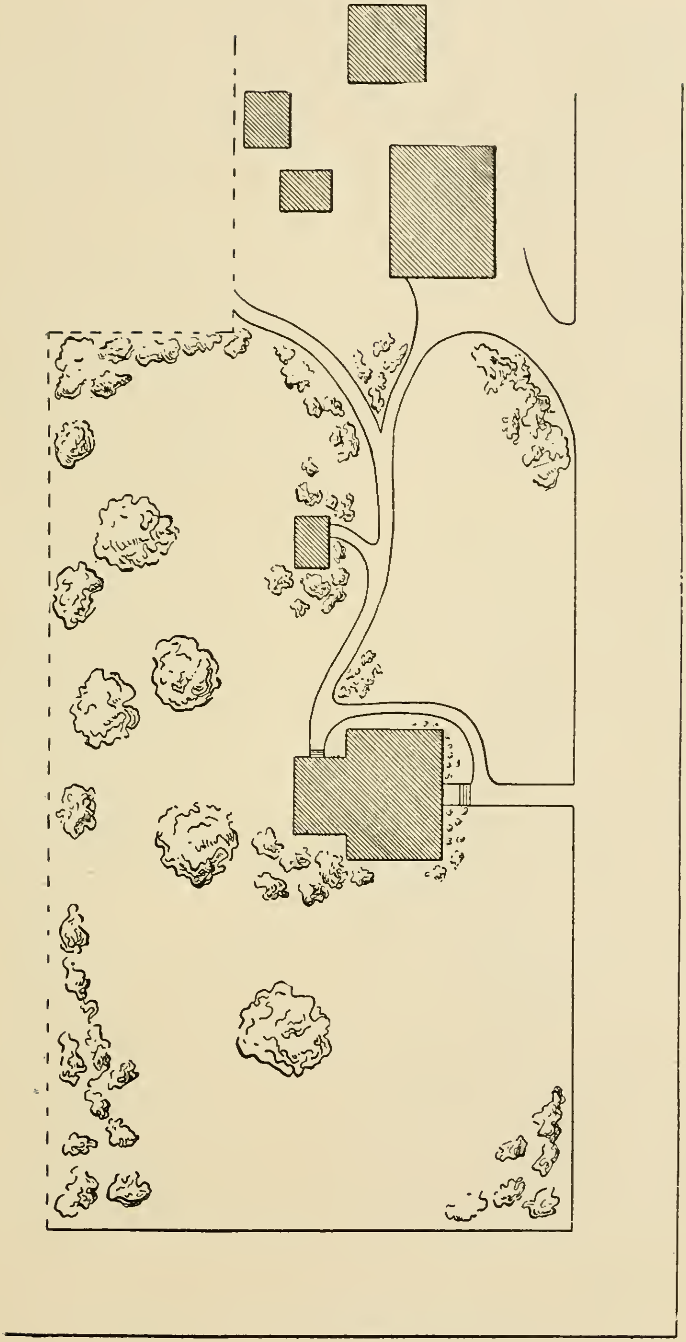

Fig. 84. IMPROVEMENTS SUGGESTED FOR FIG 83.

altitudes below 3500 feet the Carolina poplar. Good evergreens are Douglass spruce, Engleman spruce, Colorado blue spruce, Norway spruce and native pines. The evergreen when once established and large enough to shade the ground will grow well without artificial irrigation. They are also valuable trees as wind breaks, mixed with fast growing deciduous trees as the willows or cottonwoods. The Colorado blue spruce makes a beautiful lawn tree when planted alone.

Good shrubs for planting along the borders and in groups are native choke cherry and service berry, lilacs, caragons, mountain maple and native thorns, English buckthorn, tatarian honeysuckles and the green and purple leaved barberries. The best ornamental trees for planting as specimens or near the house are European white birch, mountain ash, Bolleana poplar and Colorado blue spruce.

In planting any of these trees to produce the most natural effects the large groups should be placed along the borders with only a few good specimens near the house or upon the lawn.

Beautiful and hardy perennial plants suitable for planting on the lawn in groups or borders are peonies, foxgloves, hollyhocks, Iceland poppies, larkspurs, anemone, columbines, Shasta daisies, California poppies, Gaillardia and pyrethrum. Among the best tender perennials and annuals or plants which have to be started each year are geraniums, pansies, asters, lobelias for borders, and sweet peas. Good descriptions of these flowering plants, giving the color of flowers, time of blooming and directions for growing, can be secured from reliable seed catalogues which will be sent without cost to anyone applying to the seed firms for them.

In conclusion, let us bear in mind that the important things to consider and put into practice in growing ornamental plants on the farm are: First, thorough preparation of the ground; second, continuous cultivation with a horse cultivator when possible, and with a hand hoe where a larger cultivator cannot be used; third, it will be necessary to water all plants from a well, where ditch water is not available, for at least one or two years; fourth, immediately after each watering the ground should be cultivated or hoed in order that the surface soil will not bake. A fine mulch of dust about the trunks of trees or shrubs and over the flower bed is the best thing to conserve the moisture.

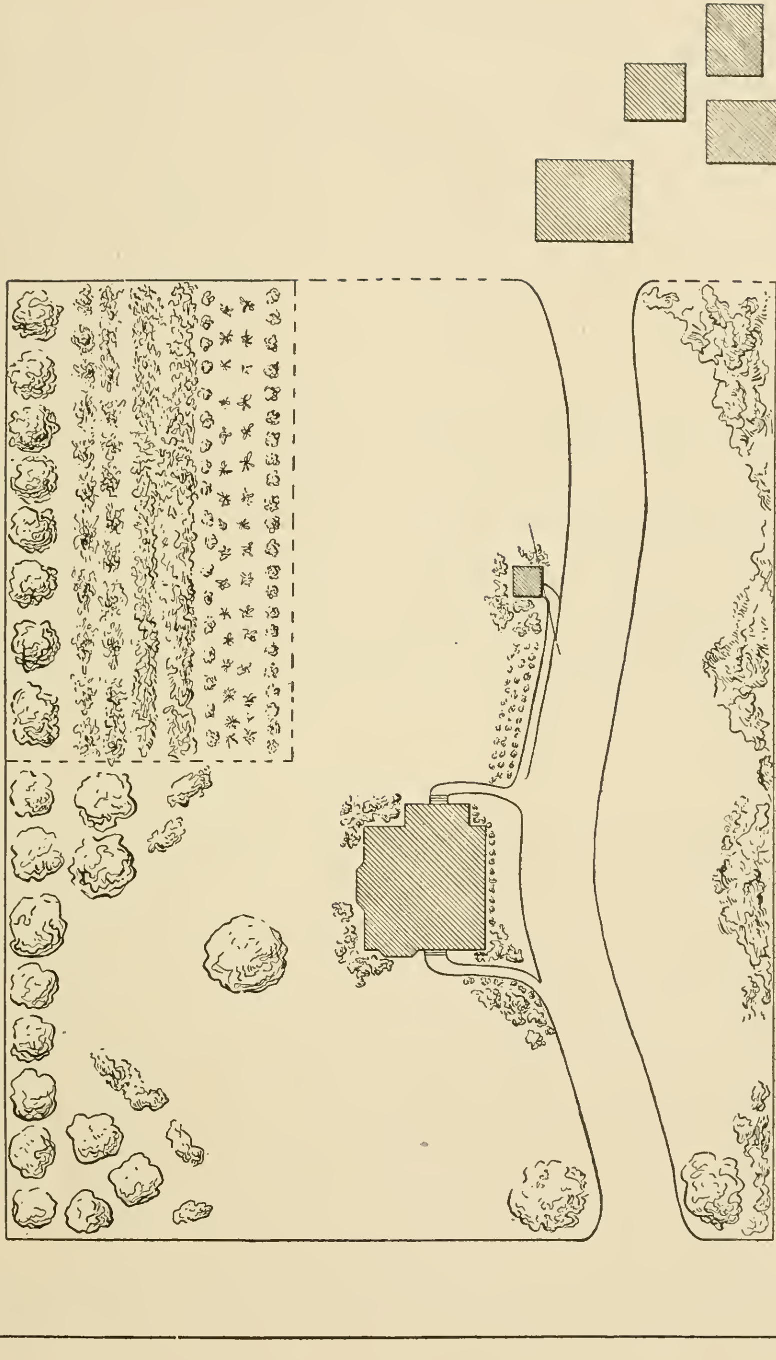

Fig. 85. PLAN FOR COUNTRY HOME GROUNDS.

CHAPTER XVIII.

PLANT DISEASES IN MONTANA.

BY PROF. D. B. SWINGLE.

Along with the methods for the growing and improving of crops it is always necessary to take every precaution to prevent loss from plant diseases and insect pests. To grow a crop and lose it before harvest time is a greater loss than to let the land lie idle. The importance of this subject is best appreciated after a severe lesson, and the wise man will profit from the mistakes of others and not wait for bitter experience to teach him.

Few realize the tax that they annually pay to the ravages of disease. Indeed it is greater for the average farmer in this country than all other taxes combined; and yet the first man to complain of an increase of taxes for better schools or better roads will be the last, as a rule, to take measures to prevent destruction from parasites.

HOW TO DIAGNOSE PLANT DISEASES.

When one finds that his fruit trees or other crops are suffering from some kind of disease he must first determine its nature—whether it is due to weather conditions or some kind of a parasite. If due to unfavorable weather, frost, excessive rains, or drouth, he may not be able to remedy the evil at once but he can at least have the satisfaction of knowing that it is not contagious and that very likely it will not be repeated the next year. If the trouble is caused by a parasite he must determine its character, especially whether it is an insect or a fungus. Without this knowledge he may carry on a full course of treatment and accomplish nothing because he has done the wrong thing. We hear of cases of this kind every year. He is like the doctor who gives quinine or physic for every ailment without first finding out what the trouble is.

There are two organizations in the state that stand ready to give the farmer every assistance possible in controlling plant diseases, namely the State Experiment Station at Bozeman and the

State Board of Horticulture with inspectors in several parts of the state. These two organizations answer many letters and frequently send men to give personal assistance in cases of severe outbreaks; but it is not their purpose to do all the work of controlling diseases and pests, and the farmer must therefore learn to be to a large extent his own plant doctor if he will succeed in the future. The time has passed when he can simply plant and let nature do the rest. By this system the parasites will get the crop and he will get what is left.

WHAT IS FUNGUS?

Many of our most destructive diseases are caused by parasitic fungi but the majority of the farmers and fruit growers of Montana have but a hazy notion of what a fungus really is. In the first place it is a plant—a very low form of vegetable life. Many are colorless or white, as our common molds; others are red like the rusts, or blue like the mould of oranges and lemons, and a few are brown or black. Nearly all have a thread-like portion called the **mycelium** which corresponds in purpose to the roots and stems of our flowering plants. The threads of this mycelium may be visible to the eye as a fine mould or they may be so small as to require a powerful microscope to enable one to see them. Many fungi are not parasites but live in humus soil or leaf mould or decaying wood.

In the case of most parasitic fungi the mycelium penetrates the host plant on which they live and injures or destroys a portion, causing the disease. Some live in the host only one year and must get a new start the next year, while others continue to live and grow in the same diseased spot year after year.

Nearly all fungi reproduce by spores, microscopic in size, which correspond in a rough way to the seeds of higher plants but are very much smaller. Even a strong hand lens or glass does not magnify enough to make them visible. They blow about in the wind like the finest and lightest dust. Like seeds they require moisture to germinate, though the finest dew drops are sufficient. Without moisture they cannot grow at all.

The treatment of fungous diseases by spraying, by fumigation and by soaking the seed in chemical solutions depends for its success upon killing these spores before they germinate or at the time of germination. After the spore has grown out into a thread and

this has penetrated the host plant spraying will not, except in rare cases, kill the fungus, which will continue to develop and produce a disease spot. The spraying solution lies on the surface. It does not penetrate the plant. Spraying is a **preventive** of disease, not a **cure.** When several sprayings are called for it is because the spores continue to fall on the plants for some time and the first spray has become washed off or has lost its strength, or new leaves and shoots have grown out since the solution was applied.

It should be remembered, then, that a fungus is a low form of plant life, that it reproduces by countless numbers of microscopic spores, and that all spraying and similar treatment must be done **before** the fungus penetrates the host plant or the treatment will be a failure.

HOW TO PREVENT PLANT DISEASES.

Every farmer should become as familiar as possible with the various methods of combating the different parasites. Those in most common use are briefly as follows: spraying, dipping, dusting, fumigation, crop rotation, burning diseased parts and the selection of resistant varieties. Each of these methods has its own peculiar value, and there are some diseases that can be controlled by a single one while all others fail. In other cases a combination treatment is necessary.

The grower should not begin treatment until he has determined specifically the nature of his trouble and has learned the methods that have proved successful for its control. Such advice may seem unnecessary but many there are, if we may judge by the past, who will not heed it but who will start in haphazard and try the wrong thing. It is not difficult to determine our more common diseases and insects and any one can learn to recognize them if he will.

It is not the purpose of this article to discuss all the known diseases, for there are hundreds on cultivated crops and thousands on wild plants. A few of the most important already known to exist in this state, or that are sure to appear, will serve our purpose better.

Descriptions of the various fungicides referred to will be found toward the end of this chapter.

Oat Smut.—This well known disease is caused by a parasitic fungus the spores of which, lying on the seed or in the soil, attack

the grain at the time it is sprouting. The threads of the mycelium grow up inside the stems of the plants and cause no visible symptoms until the grain heads out. Then, in place of oat grains, masses of black fungus spores form instead.

This disease can be almost entirely prevented by soaking the seed in a solution of formalin, obtainable at drug stores and sometimes at seed stores. One-half pound (or one-half pint) of formalin to thirty gallons of water is a suitable strength to kill the smut spores and will not injure the grain. This may be applied in any one of several ways:

A little grain may be placed on a barn floor and sprinkled by means of an ordinary watering pot with the formalin solution. A few more shovelfuls of grain are then added and sprinkled and this process kept up until the entire amount of seed is treated. It is very important to shovel the grain over and over during the process until it is all thoroughly wet. When all the grain is treated the pile should be covered with blankets, canvas or sacks to keep the formalin from evaporating and left for at least two hours, (over night will do no harm). The grain should then be spread out to dry after which it is ready to plant.

Several "smut machines" have recently been devised to save the labor of sprinkling the grain. A very successful type is shown in Fig. 86. The grain comes from the machine thoroughly wet and should be first covered with blankets, then dried as described above.

Some prefer to treat the grain in sacks and this may be successfully done. A few plunge the sacks in a large tank containing the formalin solution and leave them there for two hours. A more common method, however, is to dip the sacks of oats in the tank, moving them up and down a few times to expel the air and wet the grain to the middle, and then drain them and cover with blankets for two hours. In the warm, dry, windy weather we often have in Montana the seed can be dried in the sack and many do this. Care must be taken, however, if the weather is wet, not to let it mould. Various devices are used to make easier the dipping of the sacks of grain. Some suspend them in the middle of a pole and work a man at each end. Others have a heavy pole hinged in the middle to an upright post, and the sack is fastened to one end and worked by a man at the other end.

The "smut machine" is much the most convenient where a large amount of seed is to be treated.

Barley Smut.—This attacks the barley when the seed is germinating in much the same manner that oat smut does the oat.

The treatment is the same as for oat smut.

Wheat Smut (Stinking).—The fungus causing this disease likewise attacks the germinating grain. This disease can be recognized at harvest time by the fact that the grain, though covered by the seed coat, is black and vile smelling inside. The formalin treatment recommended for oat and barley smut will prevent this smut also.

Wheat Smut (Loose)—This smut is caused by a different fungus from the stinking smut and can be distinguished by the absence of a heavy seed coat around the smutted grain, allowing the black spores to fall out readily, and by the absence of the disagreeable odor.

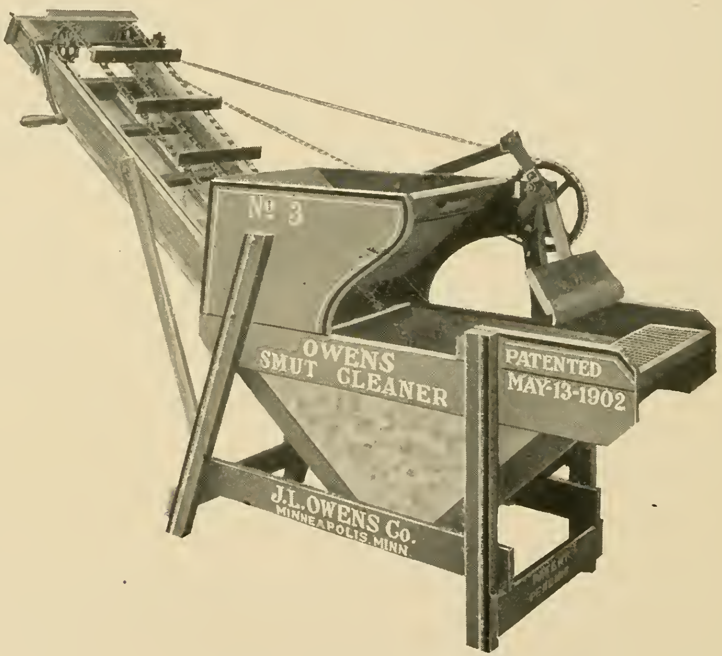

Fig. 86. SMUT MACHINE.

The loose smut attacks the wheat plant much later in life,—that is, after the head has been pushed out. Treating the seed is therefore useless. No prevention is known except to sow the field for several years to some other crop, barley, oats or clover, for example. This disease has not yet become common in Montana, though very destructive in many other localities.

The first three smuts described, however, cause heavy losses in nearly every grain-growing section of the state. Many of the most successful grain farmers always treat their seed while others, less progressive or more careless, neglect to do so and frequently lose many times the cost and labor of treatment.

Potato Scab.—This very common disease is familiar to all, causing the scabby spots on the tubers, which gives it the name. The leaves, stalks and roots are not noticeably affected. The scab reduces the yield by dwarfing the size of the tubers if badly affected, and greatly injures their salability.

Potato scab can be greatly reduced by soaking the seed for two hours in formalin solution, one pint to thirty gallons of water, (double the strength used for smuts). If, however, the soil is full of the spores clean potatoes cannot be grown in it even by treating the seed. In such a case another crop should be grown on the land for four or five years if practicable, as the disease is very persistent in the soil.

Gooseberry Mildew.—The fungus causing gooseberry mildew is mostly on the surface and appears as a white mould on the growing berries, and often the leaves and young stems also. Later in the season this turns to a greenish brown. There is a great difference in the susceptibility of varieties, the crop from one being totally destroyed, while another in the same row is entirely uninjured. The "Chatauqua" is one of the worst affected varieties.

This disease may be kept in check with a solution of potassium sulphide (liver of sulphur). The bushes must be sprayed repeatedly, however, once a week or at least once in ten days, beginning when the buds break in the spring and continuing till the fruit is nearly full grown. This may seem a good deal of trouble but small bushes, as those of the gooseberry, can be quickly sprayed if one is equipped for it and with certain varieties it is a choice between spraying and having no crop.

Plum Pocket.—The disease that goes by this name is so characteristic in its appearance that it can scarcely be mistaken. It attacks mostly the wild plum and cherry but some of the cultivated varieties suffer also. Soon after the fruit sets it begins a rapid abnormal growth and soon becomes several times the size of the healthy ones. It is hollow and the stone fails to form. Such fruits are, of course, worthless and sometimes more than ninety percent on a tree are affected.

The treatment of this disease has not been entirely successful. The mycelium of the fungus may remain alive over winter in the young twigs and start the disease again the next spring. It therefore becomes necessary in severe cases to cut off and burn all the twigs in the fall after the leaves have fallen.

Spraying with Bordeaux mixture just before the buds open in the spring has been beneficial in some cases. All diseased fruit should be burned before it decays or gets lost in the ground, as this will be a source of new infection the next spring.

Peach Leaf Curl.—This causes the leaves to become greatly distorted and deformed, slightly more fleshy and of a whitish color. As these leaves lose their power to perform their normal functions the trees and crop suffer accordingly.

Leaf curl is easily controlled but becomes very serious if neglected. Spraying with Bordeaux mixture just before the buds open and again just as the petals fall is very effective. The insecticide known as lime-sulphur-salt solution applied before the buds open has been found almost as successful.

Pear Blight.—Of the several diseases attacking the pear this is by far the most destructive. In fact it has completely ruined the industry in many important pear growing sections of the country. The attack begins in the flowers or the tender growing portions, or in wounds of any kind. It is caused by a bacterium, germ or microbe, which differs from a fungus in having no mycelium. These germs are extremely small, about the shape of rice grains, and are found in every blighted tree in countless thousands. They are carried about chiefly by insects and after a few flowers become infected it can readily be seen how rapid will be the spread through the agency of bees collecting honey.

It is usually from two to three weeks after the germ gains entrance to the tree before the disease becomes noticeable. One of

the earliest symptoms is a sudden blackening of the foliage and tender shoots, so it is commonly said that the trees look as if struck by fire. The entire leaf is blackened and soon shrivels and dries up. In this respect the disease differs from that caused by the pear leaf blister mite which produces only black spots on the leaves, with green spaces between.

From the point of attack the disease runs rapidly down the inner bark of the tree, turning it first pink, (as may be seen by cutting in with a knife), and then brown or nearly black. The bark may be killed from flower to root in a few weeks' time and a tree thus affected has but a few months to live.

Many remedies and preventive measures have been tried with this disease but most of them have failed. It can, however, be controlled or, if taken in time, completely exterminated by cutting away and burning the diseased parts. It has been held that the pear blight germ passes the winter in the diseased parts of the trees and nowhere else. If this be true, to destroy all the diseased parts will result in killing all the germs and completely freeing the orchard from the disease until it spreads in from some other locality.

This seems a very simple treatment but unless the following precautions are strictly adhered to the treatment is almost sure to fail.

1. All cutting must be done before spring opens, preferably in December.

2. Every case must be found and removed, as a single one left may start the disease again the next season.

3. All cuts must be made from six inches to a foot below the lowest diseased portion if the trees are in a dormant condition and from two to three feet below if the trees are in an active, growing condition. Many have failed by not following this rule.

4. After every cut the shears or saw must be disinfected* before another cut is made, otherwise the germs may be carried into the new wound and start the disease there. It is difficult to get common laborers to follow this rule.

Note* The best disinfectant solution is made by dissolving four small corrosive sublimate tablets in a pint of water. This can be carried in a milk bottle suspended to a belt, and applied with a swab. This solution should be made up with soft water and tin vessels should not be used. Glass, wood and earthernware are suitable.

5. Every diseased branch should be burned the same day it is cut. Otherwise ants and other insects crawling over it may carry it to healthy trees again.

6. All fallen fruit should be burned and all trees affected in the trunk should be dug out, not chopped off.

Even with these directions an inexperienced man will almost certainly make mistakes—it is almost like learning to perform a surgical operation. It is strongly advised, therefore, that when this disease appears the grower write at once to the State Experiment Station or to the State Board of Horticulture for assistance.

A determined effort is being made to completely exterminate this disease from the state and to keep it out, and it is of the greatest importance that every new case be reported at once.

Blight on Apple.—This is caused by the same germ as pear blight and the disease may spread from pear to apple or from apple to pear if conditions are favorable. There is a great difference in the susceptibility of different varieties of apples to the blight. In Alexanders, Trancendent Crabs, and a few other varieties, the disease runs much the same course as in pear trees and the symptoms are the same, excepting that the leaves and bark turn brown instead of black. These varieties, which are of great importance in Montana, will be practically wiped out unless this disease is controlled. In other varieties the blight kills the leaves, flowers and young twigs but does not often get down into the large branches.

The treatment for apple blight is the same as for pear blight but is not so easily carried out, owing to the difficulty in detecting the disease in apple trees during the dormant season.

As this disease is usually carried about on nursery stock great care should be used to get pear trees only from localities free from it.

Apple Scab.—This is one of the worst of all diseases affecting the apple. The spots first appear on the fruit a few weeks after blossoming time as small, round, olive green spots which later turn to a greenish black. As the apples grow the spots increase in size also and make the fruit extremely unsightly and absolutely unmarketable. These spots can easily be distinguished by their color from the work of the green fruit worm which gnaws the fruit, making reddish-brown, cork-colored spots. The apple scab fungus attacks the leaves also, but the spots there are not so conspicuous,

though upon close examination their character is seen to be the same as those upon the fruit. New spores are constantly being formed by the fungus in these spots and these are carried about by the wind, causing new infections.

Few, if any, of these summer spores live over winter, but the mycelium remains alive in the fallen leaves and fruit and early the next spring, before blossoming time, forms a new crop of spores. For this reason these diseased leaves and fruit should be raked and burned if possible, or at least plowed under in the fall.

Spraying is very effective in controlling this disease if it is done at just the right time. Otherwise the grower may spray and still have the scab. First, the trees should have an application of Bordeaux mixture just before the leaf buds open; a second spray of Bordeaux should, if possible, be applied just before the flowers open and a third as soon as the petals fall. This third spraying is perhaps the most important of all. After this the trees should be sprayed about every two weeks, depending upon weather conditions, for perhaps six weeks. The apples will then be large enough to resist the attack of the fungus for the rest of the season. If preferable, the first spraying, while the trees are still dormant, may be made with bluestone solution, one pound to twenty-five gallons of water, but this solution should never be applied after the buds open.

This treatment may seem to involve a great deal of spraying but a very profitable apple business may still be carried on, as thousands of growers are doing all over the United States. When the scab attacks a man's orchard he has his choice between doing this spraying and quitting the apple business. A few have been so foolish as to choose the latter.

Apple Canker.—There are several kinds of apple canker in this country but the one occurring in this state has not been studied thoroughly. It forms dead spots on the bark, especially in the crotches and around small twigs, and these spots are often wrongly attributed to sun scald. By cutting in with a knife it can be seen that the bark is dead to the wood, not simply on the surface. It is a noticeable fact that this disease may be severe one year and not appear again to any extent for several years.

Work with this disease is now being carried on at the Experiment Station and any one troubled with it should send there for later information.

Collar Rot.—This is likewise a comparatively new disease and little is known about it as yet. It kills the bark around the tree just below the surface of the ground, which has the same effect on the tree as girdling. The year following the attack the tree makes little terminal growth, the leaves are small and yellow and may dry up on the tree, and the bark is somewhat more yellow also. Work on this disease is also being carried on at the Experiment Station.

Wood Rot of Apple and Other Trees.—Very often trees die or are found broken down, and examination shows the wood to be dry rotted, with no strength. This decay is caused by fungi that gain entrance through wounds. These wounds are mostly from three causes, pruning, cultivators, and breaking of limbs by winds or an overload of fruit. These wounds, if painted with heavy white lead paint, will cause comparatively little damage but nearly every case of heart rot can be traced to neglected wounds. Painting large wounds is, in the long run, an exceedingly economical proceeding. Those less than an inch in diameter may be safely neglected.

Crown Gall of Apple.—This is seen mostly on nursery stock and appears as roundish swellings on the roots and crown of the trees. The cause of the disease is uncertain. Stock thus affected may recover in some cases but so much has failed to do so that any one would be taking a big risk to set such trees. Some nurserymen cut the galls off and then dip the roots in mud to conceal the wounds so a careful inspection is often necessary. The disease does not, however, seem to be very contagious. No remedy is yet known.

Hairy Root of Apple.—The cause of this disease is likewise not known. The affected trees produce no large strong roots but great tufts of small fibrous ones, entirely insufficient to anchor the trees securely. Such trees are worthless. Care should be used, however, not to destroy stock having many fibrous roots with large strong ones besides, as this is the best type of root system and should not be confused with the hairy root disease. Like the crown gall, this disease does not seem to be contagious to any considerable extent and no remedy is known.

A FEW IMPORTANT FUNGICIDES.

Formalin Solution (A)—(For Smuts.) Formalin, ½ pound (or ½ pint). Water, 30 gallons.

A pint of formalin is a little more than a pound but the difference is not enough to affect the results.

Formalin Solution (B).—(For Potato Scab.) Formalin, 1 pound. Water, 30 gallons.

Care should be taken that the formalin is full strength. It evaporates rapidly if exposed in an open vessel and occasionally a druggist is dishonest enough to dilute it, thereby saving a few cents at the cost of many dollars to the farmer.

Potassium Sulphide (Liver of Sulphur) Solution. **Potassium Sulphide**, 3 ounces. Water, 10 gallons.

Especially good for gooseberry, rose and other mildews.

This solution will not keep well after being made up and should therefore be used the same day.

Copper Sulphate (Blue-stone) Solution. Copper Sulphate, 1 pound. Water, 25 gallons.

This solution will keep indefinitely.

The sulphate will dissolve most readily in hot water or by suspending in a coarse bag in the top of the barrel of water, just below the surface.

This is very good as a winter spray for apple scab and other fungous diseases but it should never be applied in the summer time as it will seriously burn the foliage and fruit.

Mercuric (Corrosive Sublimate) Solution.—This is most conveniently made up by using the small tablets sold in bottles by druggists.

Four to six tablets should be used to every pint of water. Two sizes of tablets are sold. Those called for in this formula are about 3-16 of an inch in diameter and contain 1 41-50 grains of sublimate.

This solution will keep indefinitely but should not be made up in metal vessels nor with very hard water.

For sterilizing tools, etc., when cutting out pear blight.

Bordeaux Mixture. Copper Sulphate (Blue-stone), 6 pounds. Unslaked lime, 4 pounds. Water 50 gallons.

Dissolve the blue-stone in hot water or by suspending it in a sack in the top of a barrel containing half the water, i. e., 25 gallons.

Be sure the lime is fresh and not air-slaked.

Slake the lime carefully to avoid lumps and add water to make up to 25 gallons.

Strain the limewater through a coarse bag to remove the small lumps.

When ready for use mix the limewater (well stirred) and bluestone solution by pouring a bucketful of one and then of the other into a third barrel, or the tank of the sprayer, stirring the mixture constantly.

After the mixture has been made, test it by one of the following methods: (1) Hold a bright knife blade in it for five minutes and if it shows a slight copper plating the spray may burn the leaves and fruit. More lime should be added and the test made again. An excess of lime will not hurt the trees. (2) Take out a little of the mixture in a saucer and add to it 2 or 3 drops of a 10% solution of potassium ferrocyanide (yellow prussiate of potash), obtained at any drug store. Do not stir in these drops and if a reddish brown sediment is formed more lime should be added. The last (No. 2) is the more delicate and better test, though both usually give satisfaction.

Never use tin or iron vessels for the Bordeaux mixture. Wood, copper and brass are very good. Never use iron pumps.

The lime and blue-stone solutions, if kept in separate barrels, will hold their strength for weeks, but after they have been mixed they should be used as soon as possible. Never use tomorrow what was made up today.

Properly prepared Bordeaux mixture will rarely injure the foliage or fruit. Occasionally, however, a slight "russeting" occurs if the spraying is followed by damp weather. This happens so seldom, though, that it should keep no one from spraying.

Bordeaux mixture is the most valuable of all known fungicides and is recommended for many diseases not here described.

It should be remembered that the fungicides described above have practically no value as insecticides unless combined with Paris green or lead arsenate, and, likewise, that Paris green, lead arsenate, kerosene emulsion, tobacco solution and most other insecticides have no value in combating fungus diseases.

SPRAYING MACHINERY.

As the prevention of plant diseases depends so much upon spraying, many, particularly fruit growers, will find it necessary to have spray pumps of their own. The system of using a neighbor's outfit is highly unsatisfactory, as usually one cannot get it at the right time and will therefore spray late or not at all. By this system one can have both the trouble of spraying and diseased fruit also. Every fruit grower should have his own spraying outfit.

A great many types and sizes are now on the market. For a few small bushes a knapsack, or a bucket pump, will serve very well. These are practically useless for large trees, however, and too slow for extensive work, even on gooseberries or potatoes.

For an orchard of a few trees a hand pump attached to a barrel is very good and many use these so-called barrel pumps. For big commercial orchards, however, a large gasoline outfit is almost indispensable and much the most economical in the long run. Often the entire orchard must be sprayed inside a day or two, and in many instances the power pump has paid for itself in a single season.

It is not our purpose here to recommend any one make of spraying outfit. There are several that are first class. One should not, however, get the cheapest but the best. It pays in many things and especially in spraying machinery.

CHAPTER XIX.

EDUCATION FOR THE TILLER OF THE DRY LAND FARM.

J. M. HAMILTON.

"It is safe to say that the prosperity of our people depends directly on the energy and intelligence with which our national resources are used. It is equally clear that these resources are the final basis of national power and perpetuity. Finally it is ominously evident that these resources are in the course of rapid exhaustion." Thus spoke President Roosevelt in his opening address at the White House Conference of Governors called for the consideration of the best methods of preserving the remaining natural resources of the Republic. Some of these resources like the ores, gas, oil and coal are incapable of renewal and perish with one using. The only aid to be rendered is the arousing of a sentiment sufficient to insure economic methods of development and to stop waste in use. Other resources like the waterways, forests and the soil can be renewed, and, with right usage, may be passed on to posterity practically undiminished. This fact has been demonstrated repeatedly. Every far sighted citizen is deeply solicitous for the preservation and economic use of all natural resources. But in point of value the soil far overreaches all other natural resources combined. While forests and minerals have a direct bearing upon the social and economic conditions of the tiller of the dry land farm, the one overshadowing and essential problem for him is the conservation of the fertility of the soil.

From the beginning the policy of the United States Government has been to dispose of public lands to actual settlers on the easiest possible terms. No sooner has one region of country been occupied than another has been annexed from the wild and uninhabited territory toward the west. Each addition to the national domain has been settled and in turn subjected to a practice of wanton waste and utter disregard for the rights of unborn generations. Extensive forests which if now standing would be more valuable than the famous mines of Ophir have been felled, piled and burned. Rich mines have been exhausted, leaving nothing but denuded canyons and abandoned camps. The soil has been cropped continuously with

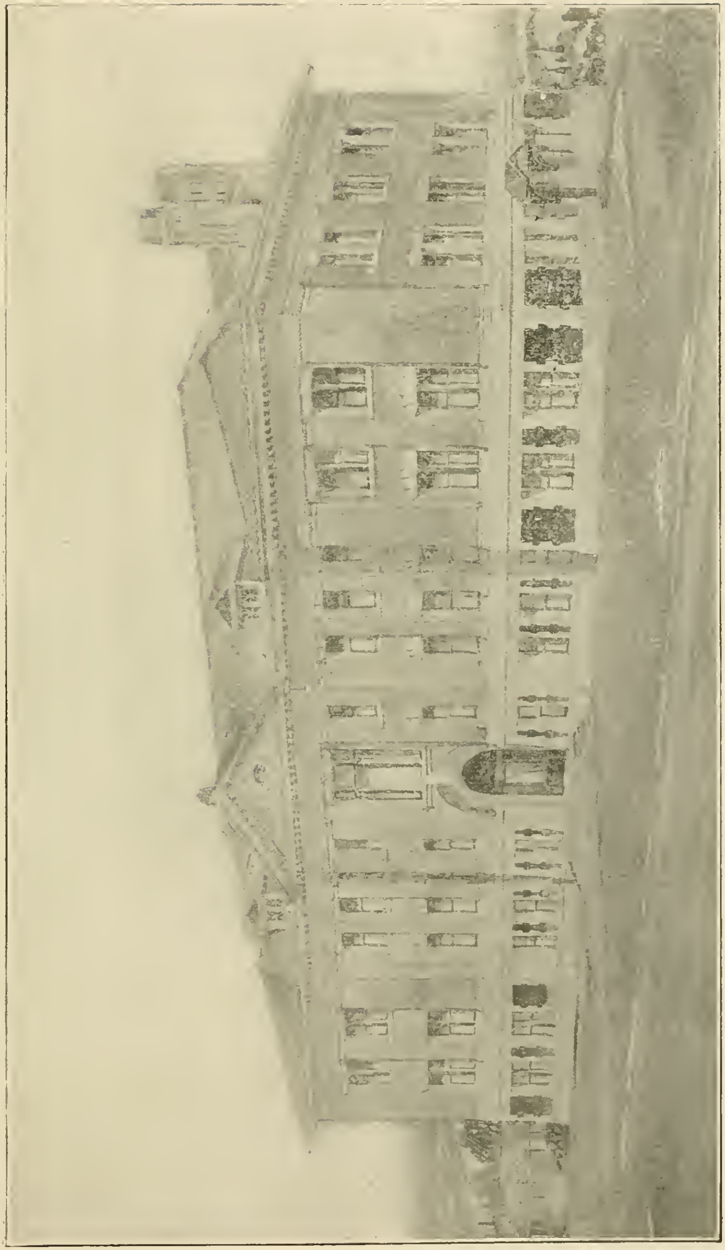

Fig. 87. AGRICULTURAL HALL, MONTANA AGRICULTURAL COLLEGE.

whatever grain would yield the largest harvest at the time, the owner well knowing that when his farm became impoverished he could move on at the next "opening." But the end has been reached. There are no more contiguous vacant lands to be annexed by the United States. Only three classes of public lands remain available to the homeseeker. First, those lands in the arid west that can be irrigated and already a point has been reached beyond which it is too expensive for the individual to put water on the land and only large corporations or the government can profitably engage in the reclamation of this class of land. Second, the swamp lands which will require costly drainage canals which must be constructed by government aid. Third, a vast plain of semi-arid lands extending eastward from the Rocky Mountains and which have neither a supply of water for irrigation nor sufficient rainfall to insure crops by the usual methods of tillage. This last class of lands is by far the most extensive and offers the cheapest and most attractive prospect to the individual homesteader. An eminent authority has estimated that by 1950 the population of the United States exclusive of our insular possessions will be 200,000,000. Where are all of these people to go? How are they to be fed? During the life of the next generation every section of the so called dry farm lands will be in demand.

A widespread belief has very generally prevailed in this country that while special training is desirable for the business and professional man, education beyond the common branches is unnecessary for the farmer. It is conceded that the surest and shortest route to success for the engineer is through a technical school, for the office man through a business course, and for the doctor by way of a medical college. The day is fast approaching when the prospective stockman, dairyman, orchardist and farmer will consider some training in agriculture just as necessary to his success. The decreasing output from the farms of some of the richest agricultural states in the union admonishes us of the pressing need of better scientific methods of farming. Pres. James J. Hill has compiled some interesting and conclusive statistics as to average crops of the last decade. During the first five years the average yield of wheat in New York was 18.4 bushels per acre and for the second five years only 17.4. The wheat yield in Kansas for a like period was 15.14 and 13.18 bushels per acre respectively. Other states give the same

Fig. 88. CATTLE BARN OF MONTANA AGRICULTURAL COLLEGE.

ratio of decrease. Some interesting experiments at the Minnesota station show the relative results of poor and good methods of cropping. A tract of land planted continuously to corn for ten years decreased in average production from 20.8 bushels per acre to 11.1 while a similar field under a system of rotation produced an average of 48.2 bushels two years out of the five included in the rotation. The only means of recuperating worn out soil and of maintaining the fertility of new lands is the application of the principles of scientific agriculture as gained through the researches and experiences of the agricultural colleges and stations. The educational policy of the country must be enlarged. An effective system of training in soil physics and fertility, rotative cropping, the use of fertilizers natural and artificial, the introduction of new plants, and the breeding of varieties now cultivated to stronger drouth resisting powers, the advantages of diversified farming, must be established and brought within reach of the tiller of the average sized farm.

In the main Montana is virgin soil. The natural resources of land have scarcely been touched. About one-half of the state lies in the vast semi-arid plain which is the last hope of the individual homeseeker. Dry land farming presents many difficult scientific problems not found in the more humid regions or the irrigated sections. The individual farmers must co-operate with the agricultural college and experiment station over a wide area of territory and for a long series of years. The best methods of moisture conservation must be practiced. The breeding and introduction of drouth resisting plants must be carried on scientifically. The diversification of farming must go on systematically. The dry land farmer must have at least the elements of scientific agricultural practice.

The so-called "consolidated school" furnishes the very best and only efficient type for the education of the farmer's family. The consolidated school as operated in many states has passed the experimental stage and has become a pronounced success. At least four districts of the prevailing size should be consolidated and a substantial building erected with modern conveniences of heating and ventilation. The site should be central and contain at least 100 acres of land. To the consolidated schools the pupils are transported free of cost in specially designed wagons. The school is graded into departments with trained and experienced teachers in charge. The principal should be a graduate of an agricultural college, live

on the school farm and conduct a demonstration farm during the vacation months. The usual common branches must be taught with special attention given to their application to country life and environment. The language exercises should be chosen from farm experience. Arithmetic problems should have reference to the measurements of farm products and markets. The supplementary reading should be selected from books on rural life. In the lower grades elementary science in the form of nature study should lay the foundation for agricultural training later in the course. History should place emphasis on the settlement of the country, inventions for use in the country and the development of transportation.

About the sixth or seventh grade a systematic course in agriculture should be commenced. This course should extend through the usual high school age and be carried on in the winter months when the young people can be spared from farm work. Parallel with this agricultural course for boys should be given a course in domestic science and arts for the girls. The agricultural course should cover the subjects of soil physics and fertility, field crops, live stock judging, feeding and breeds, gardening and orcharding, insect pests and plant diseases, veterinary hygiene and farm sanitation, farm machinery, wood and forge work, and the elements of rural economics with special reference to marketing farm produce.

The present modern high school system which has made such rapid progress in the cities has scarcely touched country people at all. The atmosphere of the city high school is hostile to country life and educates young people away from the farm. In order to avail themselves of the high schools, the country boys and girls must leave home, pay their living expenses and subject themselves to the evils of the city. As a result the city high schools and even the county high schools have but an insignificant number enrolled from the country districts. Should the city boys and girls be compelled to pay for their board and rooms not enough would apply this fall to justify opening but a small number of the magnificant high school buildings in the country or employing but a fraction of the teachers. The county high schools of Montana have failed to reach the country boys and girls largely because of the expense of attending and partially because suitable courses have not been provided. If the county high school does not furnish courses appropriate for the rural students and lessen the expense by providing dormitories with

free rooms and board at cost or privilege of light house keeping, the farmers of the state will see that the law is repealed or modified. The next legislature should pass a law authorizing consolidated schools in Montana to make provision that the high school tax may be used to support domestic science and agricultural courses in them.

The consolidated school will solve rural social problems. Next in importance after the production and marketing of farm crops stands the question of the social environment. The rural household is isolated and deprived of most of the advantages of society, even since the introduction of free mail delivery and telephones into farm houses. The library with its free books and reading room is almost unknown in the farm community. The conveniences of baths, electrical appliances and modern heating apparatus scarcely extend beyond the city limit. Musical instruments are not as plentiful among farmers' families as could be desired. Country churches are poor and Sunday schools limited. The consolidated school will naturally become the social center of community life. Near its site a post office will be established and perhaps a co-operative general store. The school shop will expand into blacksmith and wood shops for the benefit of the community. Farmers' institutes and the meetings of farmers' organizations will be held at the school. Political meetings and neighborhood gatherings of all descriptions will be attracted to such a center. In the absence of denominational organizations, a union Sunday school will be maintained. The school library will expand into a general free circulating library with a large list of books and periodicals relating to farm interests. A farmers' reading circle will be established with monthly meetings for conference and country clubs maintained for the advancement and promotion of rural projects.

The agricultural college and experiment station must assume an efficient leadership in this work and mould and unify these scattered schools into one complete, efficient system. The faculty and station staff must prepare the teachers and conduct the researches necessary to make available the best in scientific agriculture and rural economy. They must deliver lectures, hold institutes, organize and superintend reading circle and correspondence courses, to the end that farm life may become as productive in financial returns and as rich in culture and social enjoyment as the modern city.

Fig. 89. STOCK JUDGING CLASS, MONTANA AGRICULTURAL COLLEGE.

CHAPTER XX.

HOUSEKEEPING A PROFESSION.

By BELLE OSBORN.

"During the past two hundred years there has been a great industrial evolution, but in the affairs of the home there has been a revolution. Formerly the housewife was the head worker in the many home industries. With the help of the other members of the family she spun and wove the fabrics used by the household, made the clothing, boiled the soap, preserved, canned, baked—created out of raw material the simple necessities of life. Great factories now supply the products of these old time home industries at far less cost and in infinite variety, so that the family of moderate means may have a wide choice of luxuries which were denied to the rich fifty years ago."

Industrial changes have taken much of the creative work from the home, but twentieth century economic and social conditions have forced many new complications upon it.

Only recently has scientific study been given to the affairs of the household. Some schools have begun to teach the rudiments of cooking and sewing, others now give adequate courses in household economics, but the great majority of women have received no special training for their life work—that of home making. Too often women think that such knowledge will come to them by instinct or intuition but sad experiences teach them otherwise. The woman who attempts to usurp the trained nurse in charge of a patient does so at the risk of the patient's life. Results quite as disastrous to the life of the family may be expected from the women ignorant of the first principles of household management and cares.

The management of the home is a business, a profession, complex and difficult to manage. All the wisdom a woman may acquire by the most diligent efforts is needed for success in the profession of home-making.

It ranks among the professions as truly as any other occupation. It is more than a trade since one who works at a trade performs each day the task assigned, the work being planned and directed by another, thus little energy is expended in directing his activities.

It is the director who must possess and exercise the power to guide, his work being to initiate, plan and direct. This requires larger capacity and ability. It is the work of the housekeeper to initiate, plan and direct the business of the home.

The woman who announces that housekeeping is a drudgery and that she hates it and keeps as far from it as possible thus confesses that she has made a failure and that she is unequal to the task. To such it must always be a drudgery, but to her who understands the possibilities of a well ordered house and gives herself to a conscientious and intelligent study of its problems, it gives an insight into and an understanding of people and things. It has been said that whenever one's knowledge of a subject has passed the stage of drudgery and becomes a science its performance at once becomes a pleasure.

There should be no question as to the need of an education and training for the woman who selects the food and clothing for the home. The fullest and best balanced education is none too good for the one who is called upon to use and impart so varied information as is the housewife.

The food problem is perhaps the most important of all the physical problems that present themselves to the household, partly because it is so inclusive and partly because it is so vital to the welfare of the family. This problem once meant the providing of something palatable and wholesome at a cost within one's means. Today it means not only the cost and nutritive value of food materials, their composition and digestibility, but also the balanced ration, the proportion of different food principles necessary for perfect nourishment, an understanding of the principles involved in preparation of food and a knowledge of food adulterations that will insure pure food materials.

"It has been said that the prosperity of a nation depends upon the health and morals of its citizens; the health and morals of a people depend mainly upon the food they eat and the homes they live in. Strong men and women cannot be raised upon insufficient food; good tempered, temperate, highly moral men cannot be expected from a race that eats badly cooked food. Wholesome and palatable food is the first step in good morals and is conducive to ability in business and skill in trade."

It is quite true we may put food in a wrong position. We

should eat to live and not live to eat. Yet we must keep in mind that proper food, clothing and shelter are the primary conditions of health and that health is essential to the most complete happiness and to the highest usefulness.

The cost of food is also an important problem in this connection. Now economy does not mean the spending of a small amount but spending in a way that will bring the greatest returns. There are very few housekeepers that do not have to consider the question of economy. A man once said that any woman could keep house who had a bank account and did not have to consider expenses but that it would take a $5000 wife to maintain a home on $50 a month. By this he meant that in order to run a house for $50 per month it would require a woman who had been educated to make every cent go as far as possible with the best returns in health and happiness. A large percentage of families are living, or existing, on $50 a month and it is the women of these families who must learn how to invest their earnings in the most nutritious food products and how to prepare them in the most healthful way. Here two main questions are involved:

1. What proportion of income should go for food? 2. What is the minimum cost per individual of food sufficient to give the necessary nourishment? Nor is the cost of food a question of raw material alone. The amount of waste must be considered and the cost of fuel used in cooking. These are problems which every housekeeper must meet and whether she is to meet them squarely and solve them or whether she is to be overcome by them and fail determines whether or not she is a master of her profession or a slave to it.

In order to master it she must make use of everything she can that will help to a knowledge of materials with which to work. The home has a close and intimate relation to the business world in general. In buying, selling and investing the housekeeper shares in the interests of large business enterprises and only business-like methods can succeed. When cooking schools were first talked of it was thought that the housekeeper would be taught. Most of them however did not have the time or inclination; many had their own ways and methods and seemingly did not care to change; hence, it was seen that in order to do the most good the girls would have to be taught.

Now we are past the days of experimenting and have demonstrated that the woman who besides practical knowledge, has a scientific understanding of how and why things are done does not have to depend upon painful experience to teach her. She it is who finds a pleasure in her work and who does a vast good to humanity.

So let us encourage the work in the schools, not in the colleges alone but in all the schools. In order to get girls interested in such work it must begin when they are young and just commencing their other studies—in other words, it should begin in the public schools. Some people say that the courses are already overcrowded but this should not be felt as an extra study but rather as a chance to practice the other studies. It should be simply laboratory work only, where the little girl can be taught the principles of cleaning and working. Such work is thoroughly enjoyed by children and causes them to think and reason for themselves. Cooking and cleaning may, as well as arithmetic, train the powers of the child and have a practical value in after life.

If the high school is to be of practical benefit to the whole community as is intended it will not hesitate to add a course in domestic science. It is here the education of the average girl ends or where she is helped to choose her life work.

Why is it that so many girls prefer office work, clerking in stores or long hours in the factory, to simply healthy household work? Why? Because they think such work is more independent. Such is the sad state of affairs which we have to contend with and without the hearty co-operation of every woman in the land the schools alone will have hard work to remedy the evil. Generally the men are allowed to manage school affairs. It is likely they would have introduced home economics long ago if the women had urged them to do so—consequently the responsibility is theirs, no matter what way you look at it and it will continue to be theirs.

Let us think with Ellen H. Richards that "no woman's education is complete until she has a scientific understanding of the sanitary requirements of a human habitation; a knowledge of the absolute and relative values of the various articles which are used in the house, including food; a system of account keeping that will make possible a close watch upon expenses; an ability to secure from others the best they have to give and to maintain a high standard of honest work."

CHAPTER XXI.

OBSERVATION AND EXPERIENCE.

By F. B. LINFIELD.

A recent visit to several of the dry farm sub-stations of the Montana Experiment Station presented some very interesting facts as to the crop possibilities from dry farm methods in several sections of the state.

Visits were made to the sub-station on Thirteen Mile creek 30 miles north of Glendive; to that on the bench six miles southwest of Forsyth; and to that in the Lake Basin some 20 miles north of Billings. Later visits were made to the sub-station at Great Falls and to that some 25 miles northwest of Harlem.

The establishment of these sub-stations involved some problems: First, in regard to their size and location; and second, in regard to their management. The aim was first to show the possibilities of dry farming in the localities selected and second, if the undertaking showed favorable cropping results the farms could become centers of help to the farmers who settled in the neighborhood.

The Glendive sub-station was started in the spring of 1904, but for the first two years while the crops were promising, yet because of the difficulty of getting reliable help the returns were not satisfactory. Two years ago the experiment was taken up on the farm of an adjoining settler and since then the work has been well done and the results all that could be desired.

The sub-station is situated some 30 miles north of Glendive near the head of Thirteen Mile creek. There are here several townships of smooth rolling land, lying from 12 to 25 miles back from the Yellowstone river. A few settlers moved in here in the spring of 1904 and now the larger portion of the country is taken up.

The settlers in this district who have handled their land in the proper way have had good crops from the start, with all the small grains. On all the sub-stations the test plats are one-half acre in area, which is of ample size to give a safe basis of computation for field conditions.

This year the crops are not threshed at this writing, August

15th, but estimates made during a recent visit gave promise of the following yields:

Fall wheat	..40 bushels per acre
Spring wheat	25 bushels per acre
Fall rye	25 bushels per acre
Oats	40 bushels per acre
Barley, Hulless....	25 bushels per acre

These results were obtained on land summer tilled the previous year. Considering the dry hot weather from the 10th of June until harvest, the crops looked very good indeed.

At the Glendive sub-station there was also a good crop of flax, a fine growth of millet, a very promising potato crop and an excellent stand of alfalfa. An inspection of the alfalfa seeded four years before on spring breaking showed a very good stand and a crop that would go about one and one-half tons per acre.

The sub-station at Forsyth is located on a bench about six miles southwest of the town, and represents conditions similar to those of a very large district in this neighborhood.

Three years ago when the station was started there was no person living on the bench. A homesteader had moved up on his claim here, but had ceased to live on it, and this we secured for the taxes, for a period of five years. The first year a start was made and a few plats of spring crop put in. The most of the work, however, was put into getting the land ready for the next season's crop.

The returns by years are as follows:

	1907.	1908. (Estimated).
Fall wheat per acre............	53.4 bu.	45 bu.
Fall rye per acre	31.0 bu.	25 bu.
Spring wheat (Macaroni) per acre.	30.0 bu.	25 bu.
Oats per acre	60.0 bu.	50 bu.
Barley (Hulless) per acre......	33.0 bu.	30.0 bu.

These results were all obtained on land summer-tilled the year before. On the land continuously cropped the yield the past season (1908) was scarcely one-fourth of the yields obtained on the summer-tilled land.

The crops for this year are not yet harvested; but the appearance of the grain on the first of August was really a surprise to every person who saw it. At this place the rainfall for May and June had not been above normal, while the weather for May was

Fig. 90. HEADS OF DRY FARM GRAIN.

quite cool. For fully five weeks before the first of August there had been but a few slight showers of less than 1-10 of an inch, and on two occasions, for two to three days at a time, dry hot winds had blown; and yet the spring crop here, on summer-tilled land, was green and promised to fill in good shape. The fall wheat was cut and in the shock and the crop looked good enough to satisfy a farmer of the Red River valley.

Flax, corn and potatoes all looked well on the Forsyth sub-station and promised good crops.

The sub-stations in Yellowstone county are in the Lake Basin, one some 20 miles north of Billings and the other about 35 miles out from the same point. They are typical of many townships of land on this high plateau. The work has been carried on here for two years.

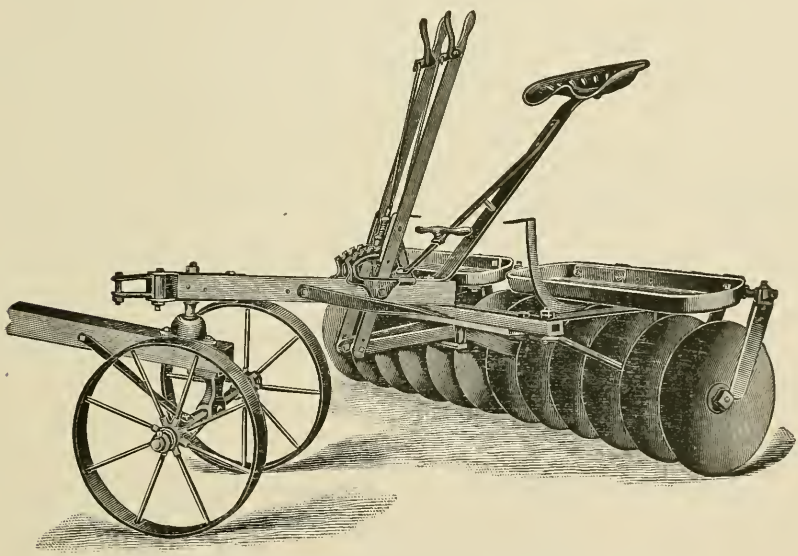

Fig. 91. DISK HARROW WITH TONGUE TRUCK.

In this district there was an excess of rain in May and continued cold weather; while June was hot with but little rain. The fall wheat here had a remarkable growth of straw, standing fully four feet high. This reduced the grain yield. The spring crops, however, looked very good. The yields are about as follows on the station nearest to Billings:

Fig. 92. HULLESS BARLEY GROWN WITHOUT IRRIGATION.

	1907	1908 (Estimated).
Fall wheat (Macaroni) per acre....		40 bu.
Fall rye per acre		25 bu.
Spring wheat (Macaroni) per acre..	27 bu.	25 bu.
Oats per acre	52 bu.	45 bu.
Barley (Hulless) per acre	39 bu.	30 bu.
Spring rye	23 bu.	20 bu.

On the station further out the crops were also very good and would average about as follows:

	1908 (Estimated).
Fall wheat per acre	40 bu.
Spring wheat (Blue stem) per acre	20 bu.
Speltz per acre	20 bu.
Hulless barley per acre	25 bu.

On this sub-station a crop that looked good and promises much for the benefit of the dry farm was a crop of Canadian field peas, planted in rows and cultivated between. They made an excellent growth and had podded well. This is a crop well worthy of further and continued trial.

The dry farm work near Great Falls was started some five years ago, but on a very small scale. Some very good results were obtained. The first start was some 16 miles out from the city; but the difficulty of getting help and the fact that we wished to try the work under a little harder conditions decided us to move nearer to the city. The station is now located just outside the city limits. The soil is light and certainly cannot be said to at all favor the dry farm practice. Last season the only work done was to get the land ready for fall and spring seeding. This year the season has been a normal one and the crops have done very well indeed. The estimated yields are about as follows:

	1908 (Estimated).
Fall wheat per acre.....	25 bu.
Fall rye per acre	20 bu.
Spring wheat per acre	20 bu.
Oats per acre	30 bu.
Barley (Hulless) per acre	25 bu.

The crop of Canadian field peas has also matured at this place and the flax and potatoes promise to yield well.

Quite a large amount of dry farming is at present done in the country around Great Falls, and especially out towards the Belt and Highwood mountains; the conditions of soil and the rainfall become more favorable as we approach the mountains.

In the spring of 1904 the people of Harlem in Choteau county decided to test the possibilities of dry farming on the high plateau above the Cherry Patch Ridge, some 25 to 40 miles north of the Milk river. This plateau, which is evidently a filled up glacial lake, extends from 60 to 100 miles east and west, and is from 10 to 20 miles wide, approaching the Canadian border on the north. This is a new country with no settlers, except the summer camp of an occasional stockman, who has located beside one of the streams that at intervals have cut a coulee across the plateau. The soil is a rich sandy loam, with a heavy sod and abundant grass. To establish a station on such a place was something of a pioneering job, and many difficulties were encountered.

The Harlem people plowed and fenced about 10 acres of land the first year. The seeds sown this first year grew well, and the results were promising, but stock broke in and ate up the crop. The next season grain was again sown, but late; and with no person to look after the crop, no results were obtained.

In the spring of 1905 the Experiment Station took hold of the work and secured a section of land from the U. S. Government. The first year's crop on this section, while not large, as was to be expected on new breaking, was yet very satisfactory. The next year the season was very late, but the crops yielded well. The crops this season are excellent, as shown in the following estimates:

	1907.	1908. (Estimated).
Fall wheat per acre	35 bu.	30 bu.
Fall rye, per acre	20 bu.	20 bu.
Spring wheat (Macaroni) per acre...	28 bu.	22 bu.
Spring rye per acre.......	16 bu.	15 bu.
Oats, per acre	50 bu.	40 bu.
Barley (Hulless) per acre	27 bu.	25 bu.

There are two or three things that these observations of the work carried on in so many parts of the state, and with such uniformly good results, appear to clearly indicate. First: that with proper soil culture and correct farm management, crops may be grown successfully and profitably on the Montana dry farm.

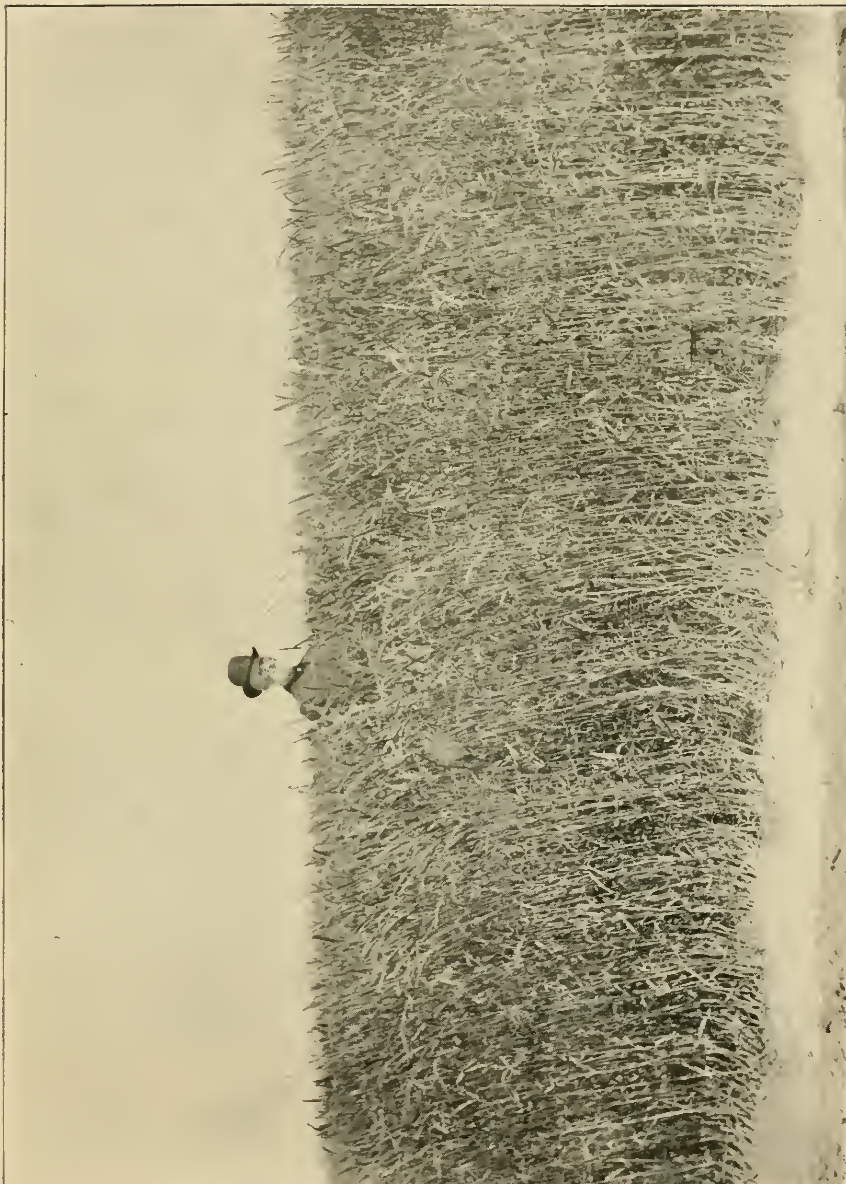

Fig. 93. DRY LAND FALL RYE.

Next, the evidence of the past two years seems to show that fall wheat is a safe crop and quite a profitable one; again, among spring crops such early ripening varieties of grain as hulless barley, macaroni wheat, early oats and flax are all sure and paying crops also; that such intertilled crops as potatoes, corn and sugar beets may be successfully grown on the dry farm. Another fact is that alfalfa promises to be a successful crop on the dry farm, though in some places it is slow in developing to a full growth. In not one place, when properly cared for, has the alfalfa failed to make a good stand, and it has continued to improve from year to year; and observations have been made for four years on such widely separated places as Cascade county and the eastern part of Dawson county.

Finally, the evidence seems to show that alternate cropping and summer tillage of the land, to conserve the moisture of two seasons for one season's crop, is the practice that will give the largest returns to the dry farmer. Advantage must also be taken of the season by seeding early and growing early ripening crops. Late ripening crops must be intertilled.

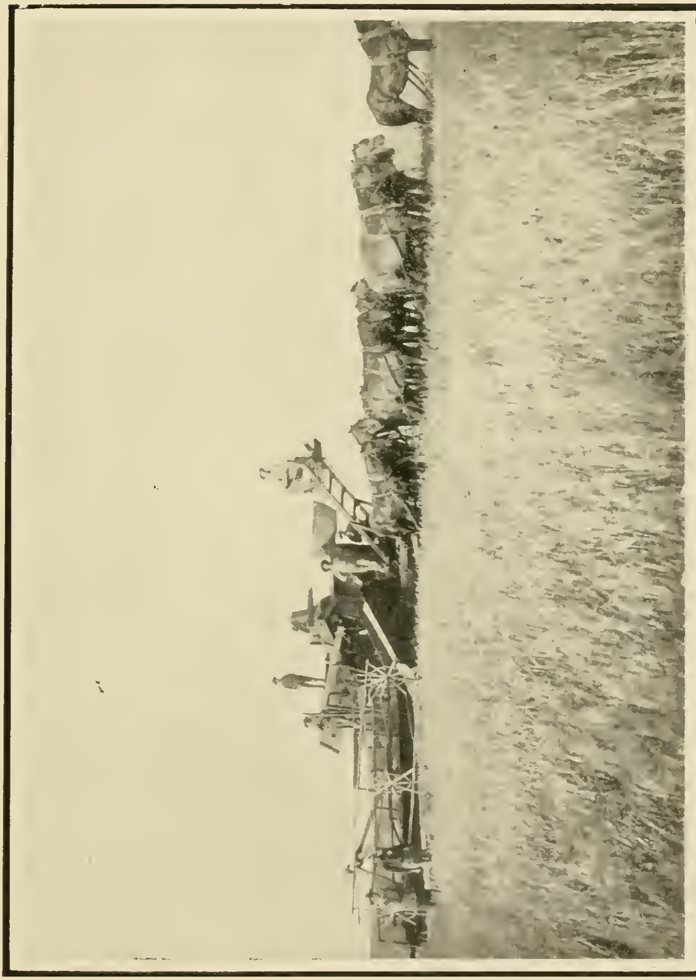

Fig. 94. JUNIOR SIDE-HILL COMBINED HARVESTER.
(Courtesy Best Mfg. Co., San Leando, Cal.)

Dear Sir:

In reply to yours of the 26th inst. asking for data on the subject of dry land farming, I enclose herewith a little bulletin showing the yields of my own crop for last year, also the yields of crops grown by various of my neighbors as they have reported them to me. The oat crops marked therein were grown on lands prepared under the Campbell system of arid land cultivation, and they tell the story for themselves. As to the other crops reported herein, including my own, the prevailing system of summer fallowing was employed. Most of our farmers in summer fallowing their land plow about an average depth of 5 to 6 inches. We have discovered, however, that the nearer we approach to the Campbell System of cultivation, the more perfect and satisfactory our crop yields.

No crops of potatoes have been reported in this bulletin. Yet, for the past three years on my dry land farm we have each year raised a very satisfactory crop of potatoes, getting a yield that would pay well on a commercial basis. Furthermore, the potatoes so raised have been of the very highest edible quality.

In my farming experience, covering a period of twelve years, we have operated both under irrigation and without irrigation. While our irrigated crops have given us a more uniform yield from year to year, yet, averaging the poor crops with the good ones grown on our non-irrigated lands, I am satisfied that we have derived more actual profit from our non-irrigated lands, considering the capital invested in them, than we have from the irrigated lands. This experience leads me to the firm conviction that dry land farming in Montana, where careful, prudent methods are employed in treating the ground and handling the crop, etc., applied to vast areas of our now unoccupied grazing land, will give us results superior to those obtained from the famous Red River Valley lands of northern Minnesota.

My experience in raising winter wheat upon non-irrigated land covers a period of eleven years, and in that time the lowest yield per acre that we have ever realized from summer fallowed lands has been seventeen bushels, while last year, as you will notice by reference to my bulletin, 419 acres of Turkey Red wheat gave me an average yield of fifty bushels; 99 acres of this crop belonged to a renter, and his yield was 58 bushels to the acre.

The average yield of winter wheat for the period of time that

I have been engaged in dry land farming is about 30 bushels. Spring fife wheat has proven less satisfactory than the winter varieties of wheat. My yields have ranged from 8 bushels of spring fife to 40 bushels. Our dry lands, under the usual system of cultivation, will not produce more than 20 bushels per acre of spring fife wheat, one season with another.

Any further information that I can give you on this subject will be freely accorded.

Yours respectfully,
ANDREW J. WALRATH.

Bozeman, Mont., May 27, 1908.
(Dic.)

The bulletin alluded to in the foregoing shows the results on the bench lands of the Gallatin Valley, without irrigation, for 1907. Eighteen farmers sowed 4,712 acres of grain, which yielded an aggregate of 198,544 bushels, an average of 42.14 bushels per acre.

The tabulated summary of yields of various grains is as follows:

	Crops Reported.	Acres.	Bushels.	Bushels per Acre.
Wheat—				
Spring fife	16	1,925	68,853	35.76
Crail fife	5	709	33,714	47.41
Turkey red	6	696	34,226	49.2
Macaroni	1	40	968	23.0
Barley—				
White Hulless	13	1,112	49,570	44.58
Oats	7	105	8,213	78.2
Rye	1	125	3,000	24.0

Three farmers followed the Campbell method closely with oats, and their crop made an average of 100.4 bushels per acre on 47 acres. Four others in the same region who are not mentioned as tillage Campbellites, had 3,497 bushels of oats on 558 acres, or 60.3 bushels per acre. Here is an apparent increase of 40.1 bushels of oats per acre, or 66½ per cent in favor of moisture conservation.

Aalt Brouwer of Bozeman grew 6,300 bushels of spring fife wheat on 150 acres of summer tilled land, or 42 bushels per acre. He obtained only 19 bushels per acre, less than one-half as much, on 70 acres of stubble ground.

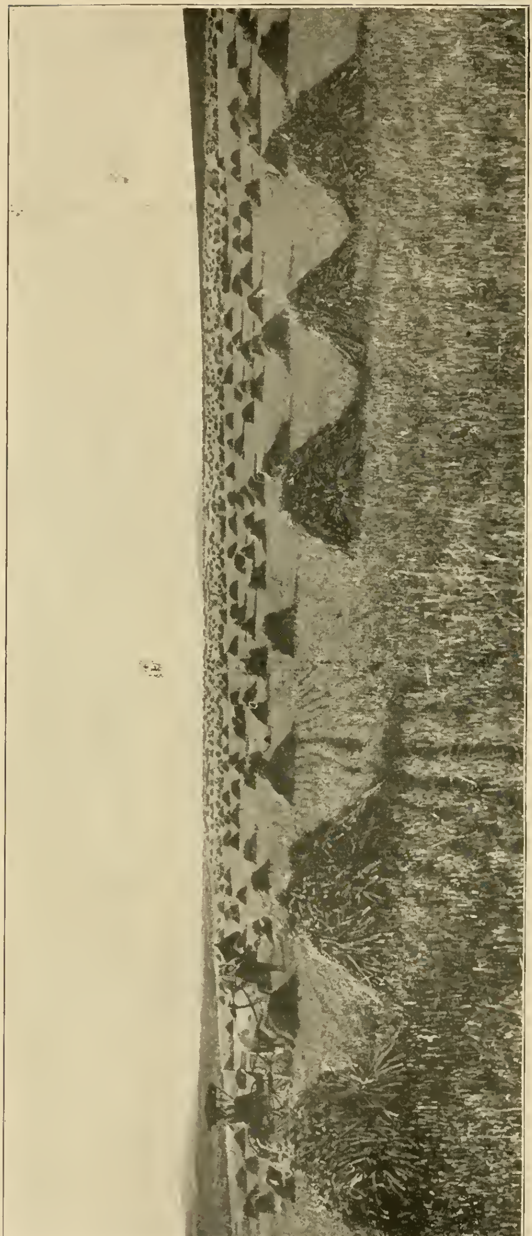

Fig. 95. 200 ACRES OF RUSSIAN BALD OR WHITE HULLESS BARLEY.
(Grown on farm of J. S. Dawes, Madison County, in 1906, without irrigation.)

DR. W. X. SUDDUTH, BROADVIEW FARM, NEAR BILLINGS.

Two fields of Kubanka wheat of five acres each yielded 27 bushels and 42 bushels of fine flinty kernels per acre. The first smaller yield was on sod plowed in the October previous and drilled in in April. The larger yield was on ground in which the wild nature was thoroughly killed, and the land, which had been sown to Canadian peas the year previous, was fall plowed, thus putting the soil in the very finest state of cultivation. Fifty acres of beardless barley made 38 bushels per acre, speltz made 31 bushels and oats made the phenomenal yield of 55 bushels and weighed 46 pounds to the bushel, or 80 bushels standard measure. The field sowed to winter wheat was "hailed out" three separate times and still made 12 bushels per acre. The hail storm was local and did not injure our other fields less than a mile distant.

Several plots of alfalfa were left for seed, and set a fine crop, but on account of the lateness of threshing much of the seed was wasted and no results can be reported. We are fully convinced from the showing made that alfalfa seed growing will be eminently successful, and it is our intention to put in a large acreage next year.

THE GARDEN.

The truck garden was all that could be asked; all kinds of garden stuff did exceedingly well. We had all the radishes, lettuce, onions, peas, beans, carrots, parsnips, beets, turnips, cabbage and summer squash we could use at headquarters all summer. We put in only a small patch of potatoes, but they made a good yield and furnished what was needed for immediate use during the summer, and there were several sacks to be dug the first of October. Everyone remarked upon the fine quality of our garden vegetables and said they had never eaten finer in any country. No one need go hungry if he will only bestir himself and till his garden sufficiently.

EXPERIENCE IN OTHER STATES.*

On the Pomeroy farm at Hill City, Kan., owned by Hon. James P. Pomeroy of Colorado Springs, "one field had been farmed fourteen years and never but one crop cut in that time. It was summer tilled in 1900, and yielded 42½ bushels of wheat in 1901. It was summer tilled in 1902, and cropped in 1903-4-5-6, averaging in the four seasons only 40 bushels per acre.

The Burlington farm at Holdredge, Neb., produced in 1905 wheat to the amount of 54½ bushels per acre on summer tilled lands, while other lands not summer tilled gave only 32 bushels." The second year, 1906, the first mentioned lands tilled in 1904 yielded 49½ bushels, against 28 bushels on the untilled lands.

In Hitchcock County, Neb., 41 bushels of wheat per acre were produced under the Campbell system of tillage, while 90 per cent of 200,000 acres in the same county was a total failure.

Henry F. Kipp, in Western Nebraska, averaged 41 bushels of wheat per acre on 20 acres with the Campbell method, in 1904, where eight months of drouth gave a loss of 90 per cent of the wheat in the same neighborhood.

*Campbell's Soil Culture Manual. Chap. XXXI.

CHAPTER XXII.

ADVICE TO NEW SETTLERS.

By F. B. LINFIELD.

In farming eastern Montana lands by the system known as "dry farming," success or failure will depend almost entirely on the way in which the work is done, because of the limited amount of the rainfall. The importance, therefore, of knowing, at least in outline, how best to do this work can not be overestimated. The following instructions, if faithfully carried out, will certainly lead to the production of good crops. They are given for three consecutive years, beginning with the breaking up of the sod.

THE FIRST YEAR.

1. If the settler is on the ground in the early spring, he may ordinarily successfully grow spring rye, bald barley, speltz, grains for hay, flax, potatoes, corn and broom corn millet—the last named crops for hay.

(a) The ground should be broken as deeply as four to five inches and well pulverized on the surface with the disk and the harrow, the harrow always following the disk at once or within a few days.

(b) It may answer to plant the potatoes and corn beneath the furrow slice when plowing, but it is much better to plant on a pulverized surface and to cultivate while growing.

(c) Rutabagas may be thinly sown broadcast and covered with a harrow.

(d) The grain crops made into hay include bald barley, peas and oats.

(e) The order of planting would be spring rye, speltz, bald barley, grains for hay, flax, potatoes, corn, millet and rutabagas.

(f) For spring crops sown on new land, the land should be broken early and the late plowing left for fall sowing or for crop to be sown the following spring, as it is not generally advisable to sow spring crops on land broken after the middle of May.

(g) A maximum crop should not be expected on land broken and cropped the same spring.

2. Some alfalfa should be sown on land prepared as above to get the crop started.

3. As much additional land as possible should be broken four to five inches for the next year's crop, until the land gets too dry for further plowing.

(a) When plowing this land, rool or disk, or, what would be better, rool, disk and harrow, before leaving the field, and in all instances follow the disk with the harrow within a few days.

(b) The ground should then be harrowed occasionally, say twice a month or oftener, until autumn, and always preferably after rain.

(c) Such treatment of summer fallow is imperative, and when carried out will insure a good crop almost any season.

4. Winter wheat of the Turkey Red variety should be drilled into a part of this land in August, and, if desired, winter rye on another part.

5. Thin seeding of cereals is at all times imperatively essential to success.

(a) Not more than the following amounts should be sown per acre: Winter wheat, three pecks, and for a dry season two pecks would be better; winter rye, six pecks; speltz, four pecks; spring rye, five pecks; flax, one peck; bald barley, sometimes called White Hulless barley, three pecks, and oats, four pecks.

(b) Not more than ten pounds of alfalfa should be sown, nor more than twelve pounds of millet seed, and probably less will give even better results.

THE SECOND YEAR.

1. The aim should be to grow all the grain crops grown for the grain or for hay as early as the ground is ready in the spring, and on land summer fallowed or that has grown potatoes or corn the previous year.

(a) The potato and corn land is best prepared by disking and harrowing.

(b) It should always be the aim to sow the seeds of cereals, including millet, with the drill, as the plants will thus get more moisture.

2. The land sown to grain crops the first year should be summer fallowed, and thus made ready for grain crops the third year.

(a) The potato, corn and pea crops may be put upon sod land spring plowed.

(b) If a pea crop is planted, or a bean crop, these may follow grain of the previous year, but they must be planted in rows and far enough apart to admit of cultivating them.

3. The aim should be to sow a considerable area of alfalfa, which is likely to be a chief reliance for hay.

(a) It should be sown on summer fallowed land of the previous year, or on that which had grown corn or potatoes.

(b) It should invariably be sown without a nurse crop, in the absence of irrigation, and usually in the month of May.

4. The aim should be to plant small fruits and trees for shelter.

(a) These should be put on summer fallowed land and kept cultivated from year to year by shallow cultivation.

(b) Soft woods, such as willow and poplar, will probably answer best for windbreaks.

5. The aim should be to break up more sod land on the fallow plan to add to the next year's crop.

6. Winter wheat and rye should be sown on fallow land as in the previous year.

THE THIRD YEAR.

1. All the cereals or grains grown for hay should, as in the previous year, be sown on summer fallow or on land that has grown a cultivated crop the previous season.

2. The cultivated crops of this year may be grown on land that had grown grain the previous year, or on newly broken sod land as desired.

3. The rest of the land that had grown grain the previous year should be summer-fallowed.

4. If possible more land should be broken on the summer-fallow plan, to add to the following year's grain crop.

5. Winter wheat and rye should be sown as in the previous seasons.

GENERAL OBSERVATIONS.

1. Should the farmer be unable to sow all these crops, he may, of course, plant such of them as will best suit his purpose, always observing carefully the conditions under which they are to be grown.

2. The crops which may most readily be turned into money are winter wheat, macaroni wheat, flax and potatoes, important probably in the order named.

3. When breaking sod land to the depth stated, not fewer than three good horses should be used.

4. The object in summer-fallowing and cultivating so much land is, to increase its power to hold moisture, the compensation coming in the larger yields obtained.

5. The necessity for sowing amounts of grain relatively small is based on the fact that the moisture is not enough to sustain the plants in a thick growth, with the result that the heads are dwarfed in proportion as the moisture is lacking.

6. The late sowing of grain crops and also growing them in succession for two years, will result in greatly decreased yields.

7. The aim should be to harrow, with a light harrow, all grain crops, say twice, once when about to come up, and once when, say 4 to 5 inches high, and to harrow corn and potatoes several times, the object being to conserve soil moisture.

8. When harrowing crops use three horses and a harrow 15 to 20 feet wide, which will do the work very speedily, and have the teeth set to slant backward so as not to drag out the plants.

Fig. 96. THE HARVEST.

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Pointers For The Dry Farmer.

1. Science and diligence will quadruple the harvest.
2. Water is of first importance. Use all possible means to prevent its waste.
3. From seven to ten inche of water can be saved for the crop by timely cultivation.
4. Disk after the harvester, as early in the spring as possible and immediately after plowing.
5. Harrow after every rain and whenever a crust begins to form.
6. Do not let weeds grow on summer-tilled land,—they use up water.
7. Harrow the grain in the spring until it is six inches high.
8. Pack the sub-surface before seeding.
9. Use drills that pack the earth about the seed.
10. Use only the best seed, select varieties and well cleaned.
11. Two or three pecks of seed per acre is enough.
12. Early ripening crops and early seeding are best for the dry arm. Late crops must be intertilled.
13. More can be produced in one crop after summer tillage than in two or three consecutive crops.
14. Market concentrated products; meat and butter pay better than forage.
15. Garden crops and shrubbery, as well as grain, may be made to thrive by thorough tillage.